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SOME PRINCIPLES OF DIRECT CURRENTS

Ohm's Law, E. M. F., Resistance, Current, Power and Circuits

The engineer of today, no matter in what kind of plant he may work or in what branch of engineering he may be interested, must of necessity be acquainted with the laws of electricity and the application of the electric current to commercial uses.

Ohm's Law.—The fundamental principle of all electric circuits depends upon three things: Electro-motive force, current and resistance—and the first law of electrical science that must be learned is Ohm's law. This law states that the current strength in a circuit is equal to the electro-motive force divided by the resistance, or putting it in the form of a formula, it is written

$$\text{Current strength} = \frac{\text{Electro-motive force}}{\text{Resistance}}$$

Let the current strength equal C, the electro-motive force, E, and the resistance, R, and the formula becomes

$$C = \frac{E}{R}$$

In practice, the unit of current is called an *ampere,* the unit of electro-motive force is called a *volt* and the unit of resistance is called an *Ohm.*

Electro-motive Force—The electro-motive force or E. M. F., as it is often written in abbreviated form, is produced in various ways. It may be converted from chemical energy, as in a battery, or it may be converted from mechanical energy by a dynamo or generator. The electric current is made to flow through a conductor by electro-motive force. As all conductors possess some resistance, and as the current moves through every part of the conductor with equal intensity, the electro-motive is expended by driving the current through each part of the conductor. The unit of electro-motive force is the volt, named after the Italian scientist, Volta, and is the electrical pressure furnished by a certain kind of battery whose poles are zinc and mercury, known as the standard cell.

Resistance.—The resistance of a wire or conductor depends upon its length and area of cross section. The resistance of a wire is directly proportional to the length and inversely proportional to its area; that is, a wire two feet long would offer twice the resistance of a wire one foot long, and a wire whose diameter is twice the diameter of another wire, would have only one-fourth the resistance, providing the wires were made of the same material.

Conductivity or conductance is the reverse of resistance, and is used to designate the conducting power of any size wire of any material. The relative conductivity of different metals, with copper as standard, is shown in Table I.

TABLE I.

	Conductivity	Resistance
Silver	102	.98
Copper	100	1.00
Gold	77	1.3
Aluminium	64	1.5
Zinc	30	3.3
Brass	22	4.5
Iron	16	6.2
Platinum	11	9.9
Lead	9	11.1
Mercury	1.6	63.2
German Silver (18 per cent. Nickel)	5.5	18
German Silver (30 per cent. Nickel)	3.6	28

The unit of resistance is the Ohm and is based upon the resistance of a column of mercury 41.85 inches long and weighing 223 grains at 32 degrees Fahrenheit.

Circular Mil System.—Since the conductivity of a conductor varies with its cross-sectional area, the mil or circular mil furnishes a system of designating cross-sectional area of an electrical conductor which has been universally adopted. The length of one-thousandth of an inch is a linear mil or simply a mil. The area of a circle one-thousandth of an inch in diameter is one circular mil.

A wire of copper of commercial purity, one foot long and one circular mil in cross-sectional area, has a resistance of 10.79 Ohms at a temperature of 75 degrees Fahrenheit, so that if a wire's cross-sectional area is known, its resistance can be determined by simple division, as the resistance varies inversely as the cross-sectional area of a conductor; therefore, if the resistance of a wire of one circular mil area is divided by the circular mils in the area of another wire of same length, the result will be the resistance of the latter wire.

Wire Gauges.—There are various wire gauges in use which

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are based upon the cross-sectional areas of the wires, each size being designated by a number. The numbers range from No. 0000 up to No. 36, and so on, the lower the number, the larger the diameter of the wire and the lower the resistance. The wire gauge generally used in the United States for copper wire is the Brown and Sharp gauge, usually called "B & S. wire gauge" or "American wire gauge." The Birmingham or Stub's gauge is sometimes used, but is not so much heard of as formerly. A table of the resistance of bare copper wire with its different properties will be found in Table II.

In studying the table it will be noticed that the weight and area about double with every three numbers.

Rule for Resistance.—If the wire table is not handy, the resistance of pure copper wire can be found by multiplying its length in feet by 10.5 and dividing the product by the cross-section in circular mils.

Current.—The intensity of the current flowing through any circuit is measured in amperes, and is the direct result of the electro-motive force and resistance of the circuit. The existence for any length of time of a current of electricity always implies the existence of a circuit. When a current is passing

TABLE II.

PROPERTIES OF BARE COPPER WIRE.

Brown & Sharpe Gauge.						Birmingham or Stubs Gauge.
Number.	Diameter in parts of an inch.	Diameter in mils.	Area in circular mils.	Weight in pounds per 1000 feet.	Resistance in ohms per 1000 ft. at 60° F.	Diameter in mils.
0000	.46	460.	211 600	624.	.048	454
000	.4096	409.6	167 800	546.	.061	425
00	.3648	364.8	133 100	437.	.076	380
0	.3249	324.9	105 500	350.	.096	340
1	.2893	289.3	83 690	272.	.122	300
2	.2576	257.6	66 370	244.	.153	284
3	.2294	229.4	52 630	203.	.194	259
4	.2043	204.3	41 740	172.	.245	238
5	.1819	181.9	33 100	146.	.307	220
6	.1620	162.	26 250	124.	.388	203
7	.1443	144.3	20 820	98?	.491	180
8	.1285	128.5	16 510	82.	.621	165
9	.1144	114.4	13 090	66.	.783	148
10	.1019	101.9	10 380	54.	.979	134
11	.0907	90.74	8 243	43.	1.229	120
12	.0808	80.81	6 530	35.	1.552	109
13	.072	71.96	5 178	27.	1.964	95
14	.0641	64.08	4 107	21.	2.485	83
15	.0571	57.07	3 257	15.	3.133	72
16	.0508	50.82	2 583	12.	3.914	65
17	.0453	45.26	2 048	10.	5.028	58
18	.0403	40.3	1 624	7.3	6.363	49
19	.0359	35.89	1 288	5.3	7.855	42
20	.032	31.96	1 022	3.7	9.942	35
21	.0285	28.46	810.1	3.1	12.53	32
22	.0253	25.35	642 4	2.4	15.9	28
23	.0225	22.57	509.5	1.9	19.93	25
24	.0201	20.1	404.	1.5	25.2	22
25	.0179	17.9	320 4	1.2	31.77	20
26	.0159	15.94	259.8	1.0	40.27	18
27	.0142	14.2	201.5	0.7	50.49	16
28	.0126	12.64	159.8	0.6	64.13	14
29	.0113	11.26	126.7	0.51	79.73	13
30	.01	10.03	100 5	0.43	101.8	12
31	.0089	8.93	79.7	0.30	128.5	10
32	.0079	7.95	63.21	0.24	159.1	9

through an electric circuit, electro-motive force must be expended to drive it through, as the resistance of the circuit opposes the transmission of the current and the current driven by electro-motive force through a resistance indicates electric energy.

Heat Developed by a Current.—When a current does work in overcoming a resistance, the work performed is converted into heat. This production of heat causes a rise of temperature in the conductor and the temperature will continue to rise until the heat generated is exactly balanced by the rate of dissipation of the heat by conduction, convection and radiation. The necessary resistances of electrical machines involve the production of heat in their operation, which causes a rise of temperature, but as insulating materials can only stand moderately high temperatures, such machines must be designed without becoming too hot, which is accomplished by increasing the radiating surface and by supplying radiation.

TABLE III.

TABLE OF SAFE CARRYING CAPACITY OF INTERIOR WIRES.

Size of Wire, B. & S. Gauge.	Circular Mills.	Current in Amperes.	
		Rubber Insulation.	Other Insulations.
14	4,107	12	16
12	6,530	17	23
10	10,380	24	32
8	16,510	33	46
6	26,250	46	65
5	33,100	54	77
4	41,740	65	92
3	52,630	76	110
2	66,370	90	131
1	83,690	107	156
0	105,500	127	185
00	133,100	150	220
000	167,800	177	262
0000	211,600	210	312
300,000 CM.	300,000	270	400
500,000 CM.	500,000	390	590
1,000,000 CM.	1,000,000	650	1,000
2,000,000 CM.	2,000,000	1,050	1,670

The utilization of this heating effect is illustrated in the incandescent lamp, electric stoves, cooking utensils, car heaters, soldering irons, etc. Wires carrying current may become heated so as to become dangerous, so that the wires are limited as to their safe carrying capacity, as shown in Table III. Wires smaller than No. 14 are never used in wiring except for special purposes.

Power.—The unit of electrical energy is called the watt and is the amount of power expended when one ampere is flowing in a circuit at a pressure of one volt. It is equivalent to $^1/_{746}$ of one horse power. The number of watts utilized in any circuit can be found by multiplying the drop of voltage by the current passing through it, or by squaring the current and multiplying by the resistance or

$$\text{Watts} = EC = C^2 R$$

For commercial currents and voltages the watt is a very small unit, so that a kilowatt (= 1,000 watts) is generally used as the unit of electrical power. It is represented by the abbreviation K. W. A horse power is equal to 746 watts, or approximately three-fourths of a K. W.

Electric Circuits.—Ohm's law, $E = C R$, states that with constant current the electro-motive force varies directly with the resistance, so that whenever the resistance in the circuit is changed, the electro-motive force will change. This is known as a constant current circuit, a typical illustration of which is an arc lamp series system, the more lamps there are in series, the more energy must be expended.

The constant potential circuit maintains a fixed difference of potential at the terminals of any apparatus, and is illustrated by the ordinary incandescent lamp system.

621.05 v. 11

Resistance of Circuits.—When a circuit consists of various parts, all of different resistances, but connected in series, forming a single path, the total resistance of the circuit is the sum of all the resistances. When a circuit is in branches, that is, connected in parallel, each of the parallel paths must be calculated separately.

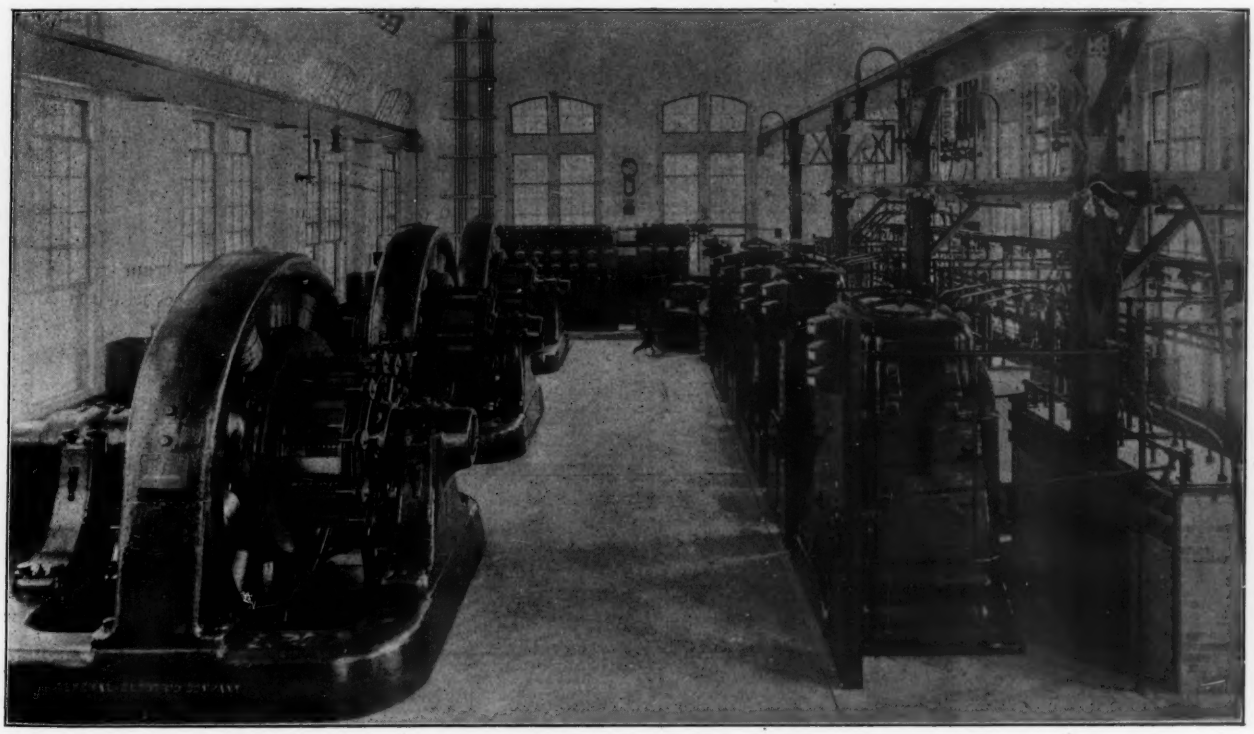
The resistance of any number of wires in parallel is equal to the product of the resistance of each circuit divided by the sum of those same resistances. For instance, suppose the resistance of the three parallel circuits R_1, R_2 and R_3 is to be obtained; then the resistance which, when substituted for the three resistances, will give the same value of current flowing through it represented by the formula

$$\frac{R_1 R_2 R_3}{R_1 + R_2 + R_3}$$

In the case of two similar wires connected in parallel, the resistance is reduced one-half.

ROTARY CONVERTERS FOR RAILWAY SERVICE

The modern railway power house utilizes alternating currents extensively at the present time, whether generated by the direct-conected alternator with reciprocating engine or with the steam turbine, internal combustion engine or hydraulic turbine in the hydro-electric power transmission plant. The two-phase or three-phase current is conducted over the high-tension power transmission lines to various sub-stations, and is reduced in pressure by step-down transformers and changed from an alternating to a direct current of 500 to 600 volts pressure for use on the trolley wire or third rail. The accompanying illustrations show the interiors of the Brockton sub-station of the Old Colony Street Railway Co., at Brockton, Mass., and the New York Central sub-station, which indicates arrangement of the converter and switchboard supplying current.



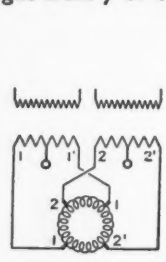
Brockton Sub-Station, Old Colony St. Ry. Co., Brockton, Mass.

At the Brockton sub-station, the three rotary converters shown are 10 pole machines of 750 kilowatts each. They operate at a speed of 300 revolutions per minute and supply a continuous current to the railway feeders at 600 volts pressure. The step-down transformers shown at the right in the illustration are 825 kilowatts capacity each. These step-down transformers are supplied with an alternating current having a frequency of 25 cycles per second, and the transformers lower the pressure from 13,200 volts to 430 volts, the current being conducted to the rotary converters at the latter voltage.

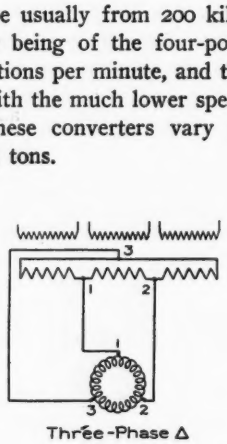
From the transmission lines connecting the sub-stations with the railway power house, the current is always first reduced in pressure by static step-down transformers, with the two-phase, three-phase or six-phase connections, according to the service provided for the railway in question. The two-phase, three-phase, T, Y or delta connections, and the six-phase diametrical, delta, T and Y connections of the transformers to the rotary converters, are well indicated in the accompanying drawings, figures 1 to 8, the first three being those ordinarily

employed.

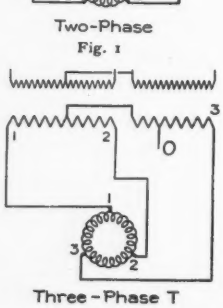
The rotary converters range in size usually from 200 kilowatts to 1,500 kilowatts, the former being of the four-pole, time-operating at speed of 750 revolutions per minute, and the latter of the 12 pole time-operating with the much lower speed of 250 revolutions per minute. These converters vary in weight from 7 or 8 tons to 40 or 45 tons.



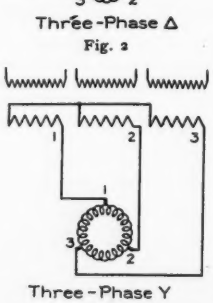
Two-Phase
Fig. 1



Three-Phase Δ
Fig. 2



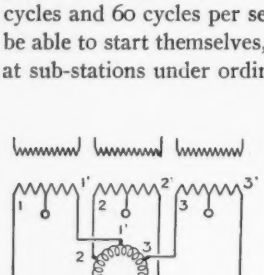
Three-Phase T
Fig. 3



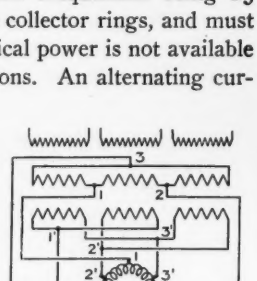
Three-Phase Y
Fig. 4

Transformer Connections

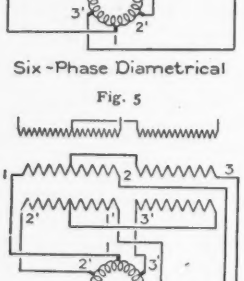
The converter receives the alternating current, usually three-phase or six-phase, the most common frequencies being 25 cycles and 60 cycles per second at the collector rings, and must be able to start themselves, as mechanical power is not available at sub-stations under ordinary conditions. An alternating current is supplied directly to the armature windings in the General Electric Rotaries, this being first impressed on the conductors at a lower voltage than that used when the machine is under full speed and in synchronism with the power house alternators. Low voltage taps are provided on the transformers, and by manipulating the proper switches the lower voltage current is conducted to the rotary converter windings, the full voltage being switched on when the machine is up to speed.



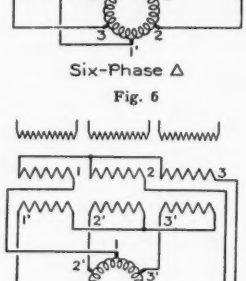
Six-Phase Diametrical
Fig. 5



Six-Phase Δ
Fig. 6



Six-Phase T
Fig. 7



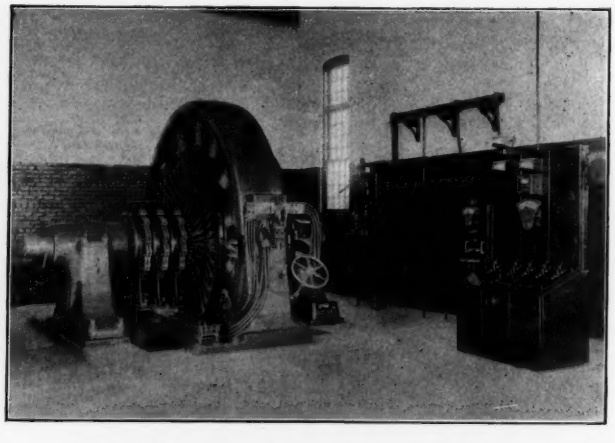
Six-Phase Y
Fig. 8

Transformer Connections

Other makes of rotaries are provided with small induction motors to start them, these being thrown out of service when synchronism has been obtained and the rotaries are in operation from the source of supply. It is maintained that the efficiency and stability of operation are increased and the heating is somewhat reduced by using six-phase windings for machines of large construction. Machines of over 500 kilowatts are therefore provided generally with six-phase windings, and those of smaller capacity with three-phase.

An interesting feature in the construction of the rotary converters built by the General Electric Company is the automatic oscillator provided, which is a mechanical end play device arranged to distribute the wear on the surface of the commutator and collector rings. By giving the armature a small reciprocating motion parallel to the direction of the shaft, the brushes are prevented from wearing grooves in the rings and commutator.

In some cases it is desirable to supply a converter with a



Sub-Station showing Converter and Switchboard,
New York Central R. R.

direct current and take from it an alternating current as a generator, it then being called an inverted converter. This reverse operation may be readily accomplished, and in many instances this is a most important feature; the rotary converter being really a direct-current generator with additional collector rings connected to the proper points on the armature windings. In addition to the commutator, the current enters the armature windings through the collector rings and is supplied to the feeders as a direct current after being rectified by the commutator.

The use of the rotary converter is now almost universal for railway service in the United States at the present time, where alternating currents are employed for long distance power transmission for traction work. This system, with numerous sub-stations and a number of power stations, will be employed in the electrification of the New York Central Railway and other American steam railway lines soon to be operated by electric power.

Factors Affecting Compressor Capacities and Efficiencies

The work performed by an air compressor is, broadly speaking, that of increasing pressure of the air (or other gas) from a lower to a higher stage by reducing its volume or compressing it into smaller space. Usually in air compressor practice the lower or initial pressure is the "atmospheric pressure" at point of location of compressor, while the higher or terminal pressure is fixed by the requirements of the particular case, and may be anywhere from 10 to 30 pounds (gauge pressure) per square inch, as in blowing engine practice, up to 80 to 100 pounds per square inch for rock drills, pneumatic tools, etc., and up to 1,500 to 2,000 pounds per square inch, or even higher, for special purposes. Compressors which work against pressures under 30 pounds gauge are usually called blowing engines. Atmospheric pressure (or zero gauge pressure) equals 14.7 pounds absolute pressure per square inch at sea level (equivalent to 30" barometer), and becomes less as the altitude above sea level increases, the decrease being approximately one-half pound, or one inch in mercury column, for each 1,000 feet increase in altitude. As the work of compression depends upon the initial and terminal absolute pressures (absolute pressure being equivalent to gauge pressure plus atmospheric pressure) the altitude at which the compressor is to work is of great importance and should always be taken into consideration.

When air is compressed into a smaller volume, if the temperature remains constant, the pressure increases directly in proportion to the decrease in volume; that is, if the volume is one-half, the pressure will be doubled; if one-third, the pressure will be trebled, and so on for any decrease in volume. There is, however, another and most important factor in the problem which must be considered in all cases except the lowest terminal pressures, viz.: the increase in temperature and consequent increase in volume due to the heat developed during compression. When air is compressed, the work done during compression is converted into heat, which must be taken up by the air compressed, the result being to very materially raise its temperature and increase its volume, thus adding largely to the work required to be done. Without going into a theoretical discussion of this factor in the problem, a brief statement of facts will show its great importance.

If air at atmospheric pressure and 60° Fahrenheit could be compressed to 100 pounds gauge pressure, and all the heat due to the work of compression taken away as fast as generated, so that the temperature during compression would remain constant, the mean effective pressure during one stroke of the air piston would be 30.2 pounds. If, on the other extreme, none of the heat due to the work of compression is taken away, the mean effective pressure during the stroke will be 41.6 pounds and the terminal temperature will reach 485° Fahrenheit. As the power required for compression is directly proportional to the mean effective pressure, it will be seen that the additional power required in the latter case is 37½ per cent. of that in the former. In practice, neither extreme can be reached, for it is impossible to completely cool the air during compression, and, on the other hand, some of the heat of compression will be radiated; but the lower extreme is the ideal, and the nearer it can be approached, the more economical the compressor will do its work.

Various plans for taking away the heat during compression, such as injecting a spray of water into the cylinder, circulating cooling water through the piston and around the heads and cylinder barrel, etc., have been tried. The use of the cooling spray, or so-called "wet compression", has long since been abandoned, as has also the plan of circulating water through the piston, for the disadvantages more than offset the possible gains. Cylinder heads and barrels are still water-jacketed, not so much on account of the heat that can be taken from air as to keep the cylinder cool enough for proper lubrication. The most effective means for taking away the heat of compression and reducing the amount of power required consists in dividing the compression into two or more stages, depending upon the terminal pressure desired, and cooling the air as much as possible between stages by means of suitable cooling apparatus, the water-jacketing of the cylinders and heads being retained for the reason above stated. Where the work of compression is done in two or more cylinders, it is customary to so fix the ratio of cylinder volumes as to divide the work

Mean Effective Pressure and Indicated Horse Power Required to Compress a Cubic Foot of Free Air (Adiabatically) from Atmospheric Pressure (14.7 Lbs.) to Various Gauge Pressures. Initial Temperature of Air in each Cyinder taken as 60° Fh. Jacket Cooling Not Considered.

Gauge Pressure Pounds.	Absolute Pressure Pounds.	Ratio of Compression.	Single Compression		Two Stage Compression.		Per Cent. of Power Saved by Two Stage Over Single Compression (Theoretical).
			Mean Effective Pressure. Friction Included.	Indicated Horse Power per Cubic Foot. Free Air Friction Included.	Mean Effective Pressure per Square Inch Reduced to Low Pressure; Air Cylinder. Friction Included.	Indicated Horse Power per Cubic Foot. Free Air Friction Included.	
5	19.7	1.34	5.12	.022	.....	....	....
10	24.7	1.68	9.44	.041	.....	....	....
15	29.7	2.02	13.17	.057	.....	....	....
20	34.7	2.36	16.44	.071	.....	....	....
25	39.7	2.70	19.47	.085	.....	....	....
30	44.7	3.04	22.21	.096	.....	....	....
35	49.7	3.38	24.72	.108	.....	....	....
40	54.7	3.72	27.05	.118	.....	....	....
45	59.7	4.06	29.21	.127	.....	....	....
50	64.7	4.40	31.31	.136	.....	....	....
55	69.7	4.74	33.23	.145	.....	....	....
60	74.7	5.08	35.10	.153	.....	....	....
65	79.7	5.42	36.91	.161	.....	....	....
70	84.7	5.76	38.59	.168	33.71	.147	12.7
75	89.7	6.10	40.25	.175	34.99	.153	13.0
80	94.7	6.44	41.80	.182	36.15	.158	13.5
85	99.7	6.78	43.27	.189	37.32	.163	13.8
90	104.7	7.12	44.71	.195	38.36	.167	14.2
95	109.7	7.46	46.12	.201	39.41	.172	14.5
100	114.7	7.80	47.46	.207	40.48	.176	14.7
110	124.7	8.48	50.09	.218	42.34	.185	15.4
120	134.7	9.16	52.53	.229	44.20	.193	15.9
130	144.7	9.84	54.87	.239	45.83	.200	16.5
140	154.7	10.52	57.08	.249	47.46	.207	16.9
150	164.7	11.20	59.18	.258	48.99	.214	17.2
160	174.7	11.88	.....	....	50.39	.219	....
170	184.7	12.56	.....	....	51.66	.225	....
180	194.7	13.24	.....	....	52.95	.231	....
190	204.7	13.92	.....	....	54.22	.236	....
200	214.7	14.60	.....	....	55.39	.241	....
250	264.7	18.00	.....	....	60.76	.264	....
300	314.7	21.40	.....	....	65.20	.283	....
350	364.7	24.81	.....	....	69.16	.301	....
400	414.7	28.21	.....	....	72.65	.317	....
450	464.7	31.61	.....	....	75.81	.329	....
500	514.7	35.01	.....	....	78.72	.342	....
550	564.7	38.41	.....	....	81.30	.354	....
600	614.7	41.81	.....	....	83.75	.364	....

equally between the cylinders. By using two-stage compression and cooling the air between the stages to its initial temperature (60° Fahrenheit), without considering the cooling by water-jacketing, it is possible to reduce the mean effective pressure to 35.5 pounds as compared with 41.6 pounds in the

Relative Volumetric Efficiencies at Various Altitudes Above Sea Level.

Altitude Above Sea Level in Feet.	Barometer in Inches.	Percentage of Volumetric Efficiency.	Decreased Power Required, 80 Lbs., Single Stage Per Cent.
0	30.00	100	.000
500	29.45	98.5	.015
1000	28.90	97	.025
1500	28.35	95.5	.04
2000	27.78	94	.05
3000	26.75	91	.07
4000	25.75	88	.09
5000	24.78	85	.11
6000	23.86	82	.13
7000	22.97	79	.14
8000	22.10	76	.16
9000	21.30	73	.17
10000	20.60	70	.18
11000	19.75	68	.20
12000	19.00	65	.21
13000	18.30	62	.23
14000	17.60	59	.24
15000	16.95	57	.25

case above given, which is equivalent to a saving of 15 per cent. At the same time the terminal temperature will be only 245° Fahrenheit instead of 485° Fahrenheit. In practice the saving may be a little less and the terminal temperature somewhat higher, as the initial temperature in both cylinders will usually be higher than 60° Fahrenheit; but, after making all allowances, the figures afford an indisputable argument in favor of two-stage compression for pressures commonly used.

Another important factor in compressor design is the clearance in the compressor cylinders. It is not possible to run a compressor without some space between the piston and cylinder head at the end of the stroke, and in addition to this space there is the volume in the inlet and discharge passages between the valves and cylinder space. It is the aim of all good designers to make this clearance space as small, in proportion to the volume swept through by the piston, as possible; for at the end of the stroke the clearance space is filled with air at the terminal pressure which must expand back to the initial pressure before the inlet valve is opened. This is particularly important in single-stage compression, as at discharge pressures ordinarily used the expanding of the compressed air in the clearance space back into the cylinder seriously affects the volumetric efficiency of the compressor. If the volume swept through by the piston in one stroke is one thousand cubic inches and the clearance volume is twenty cubic inches, the compressor has 2 per cent. clearance. In this case, if the discharge pressure is 75 pounds gauge (89.7 pounds absolute) and the initial pressure is atmospheric pressure at sea level (14.7 pounds), the air in the clearance space will expand to six times the clearance volume, or to 120 cubic inches, and, as the clearance volume is only 20 inches, the remaining 100 travel back 10 per cent. of the return stroke before opening the inlet valve, and the actual room for the admission of free air is only 1000 — 100 = 900 cubic inches; or, as commonly stated, the volumetric efficiency of the compressor is only 90 per cent.

It is the common practice of compressor builders to call the free air capacity of their machines the volume theoretically swept through by the piston, without making any deductions; that is, if the area of the piston is two square feet and it travels 500 feet per minute, the capacity is called 1,000 cubic feet per minute. It will readily be seen that in the case above cited, if the clearance is 2 per cent. the actual capacity is only 900 cubic feet per minute, and if 1,000 cubic feet is wanted, the compressor must be speeded up to 555 feet per minute. It may be stated in this connection that in the majority of the compressors in daily use the clearance exceeds 2 per cent., and the volumetric efficiency is less than 90 per cent. The clearance also adversely affects the efficiency of the machine, for, in addition to the loss from greater friction on account of the increased speed required for a given actual capacity, the air in the clearance space in expanding to the initial pressure never gives back quite as much power as was used in compressing it. Inasmuch as with any given diameter and travel of piston the clearance space is practically a constant quantity, the longer the stroke the less the percentage of clearance. If a cylinder of 30″ diameter by 60″ stroke has one and one-half per cent. clearance and the stroke is shortened one-half, *i.e.*, to 30″, the percentage of clearance will be doubled, or 3 per cent. It is therefore better to get the required capacity by using a small diameter and long stroke rather than larger diameter and shorter stroke, even if the advantages of greater reliability in operation, durability and lower cost of maintenance and repair arising from slower rotative speed for a given piston travel are not considered. As a matter of fact these advantages, together with the increased efficiencies, will more than offset the disadvantages

Table Showing the Relative Volumes of Compressed Air at Various Pressures.

Gauge Pressure Pounds.	Volume of Free Air Corresponding to One Cubic Foot of Air at Given Pressure.	Corresponding Volume of One Cubic Foot of Free Air at Given Pressure.
0	1.00	1.00
1	1.068	.9356
2	1.136	.8802
3	1.204	.8305
4	1.273	.7861
5	1.34	.7462
10	1.68	.5951
15	2.02	.4949
20	2.36	.4236
25	2.7	.3703
30	3.04	.3288
35	3.38	.2957
40	3.72	.2687
45	4.06	.2462
50	4.40	.2272
55	4.74	.2109
60	5.08	.1967
65	5.42	.1844
70	5.762	.1735
75	6.102	.1638
80	6.442	.1552
85	6.732	.1474
90	7.122	.1404
95	7.462	.1340
100	7.802	.1281
110	8.483	.1178
120	9.170	.1090
130	9.843	.1016
140	10.52	.0950
150	11.20	.0892
160	11.88	.0841
170	12.56	.0796
180	13.24	.0755
190	13.92	.0712
200	14.60	.0684

arising from higher first cost, increased floor space and greater expense of installation.

The loss of volumetric efficiency due to clearance is less in two-stage than in single-stage compressors, because for any given capacity the first or low-pressure cylinder of the two-stage machine is practically of the same size and has the same percentage of clearance, while the terminal pressure is much lower; consequently, the expansion back into the cylinder volume is much less and the volumetric efficiency higher. This

fact affords another strong argument for the use of two-stage compressors.

Another factor affecting compressor capacities and efficiencies merits careful consideration. It is the common practice to not only rate the capacity at the full volume swept through by the piston, but to assume that the cylinder is filled at the beginning of the stroke with air at full atmospheric pressure and at no higher temperature than the outside source of supply. A moment's consideration will show that such ideal conditions are impossible of attainment. In the first place, even with an unobstructed inlet passage air will not flow into the cylinder without some difference in pressure to force it in, and when, as in many compressors, the inlet valves are of the spring-weighted poppet type, this difference as to its effect upon capacity and efficiency becomes a serious matter. Then, again, the entering air comes into contact with the cylinder walls and clearance surfaces which have become highly heated from the compression in the preceding stroke, and is thereby heated to a higher temperature than before entering. This not only reduces the volume of free air at the outside temperature which can be handled, but also raises the terminal temperature of compression. The latter effect may become cumulative, for the higher the terminal temperature the more the surfaces become heated, and the higher the entering air is heated, resulting in still higher terminal temperature. In cases where the water-jacketing is inefficient or the water circulation becomes interrupted, this cumulative effect may result in heating the compressor cylinder to a dangerous degree. It is essential to good economy that the air be brought to the compressor and gotten into the cylinder with as little heating as possible. To accomplish this the inlet ports should be short and direct and the air admitted in a solid stream and not cut up into thin sheets. Admitting the air through a hollow piston and piston rod, or straining it through metal guards which are frequently used to prevent poppet inlet valves from getting into the cylinder in case of breakage of valve stems, manifestly results in undue heating and consequent loss. In this matter of initial heating of the air, the two-stage compressor has a marked advantage over the single-stage, because the terminal temperatures are much lower, consequently the cylinder walls and clearance surfaces do not become so highly heated and the transfer of heat to the incoming air is much slower.

What has been said above applies to compressors of every type, whether for air or other gases, and no matter how driven.

Fan Blowers.

A volume blower is primarily designed to discharge air in large quantity under low pressure with the minimum expenditure of power. This requires a wide and comparatively slow running wheel. A pressure blower, on the other hand, is designed for the purpose of creating a high pressure, which may be as great as 20 ounces per square inch, while delivering a relatively small volume of air. To this end the wheel must be narrow and operated at high speed.

In operation the peripheral discharge fan sets in motion the air within it, which, acting by centrifugal force, is delivered tangentially at the outer circumference of the wheel. Air rushes in at the axial inlet to fill the space between the blades, in which there is, by the centrifugal action, a tendency to form a vacuum. The degree of this vacuum is dependent upon the circumferential speed of the wheel; and the velocity of the air discharged through an outlet of proper size is substantially equal to that of the circumference of the wheel. The fan case thus virtually becomes a reservoir from which the air escaped through the outlet.

In the attempt to force air at a given velocity through a given pipe, it is the province of the fan wheel, if employed therefor, to create within the fan case a total pressure above the atmosphere which shall be sufficient to produce the velocity and also overcome the resistance of the case and the pipe. If, however, the pipe be removed and the fan be allowed to discharge the air through a short and properly shaped outlet, the pressure necessary will, with an efficient fan, be substantially that required to produce the velocity. From the same formulae, properly transposed, the pressure due to any given velocity or necessary to its creation may be determined. The pressure thus determined is properly that which it is the purpose of the fan, employed as a device for moving air, to create.

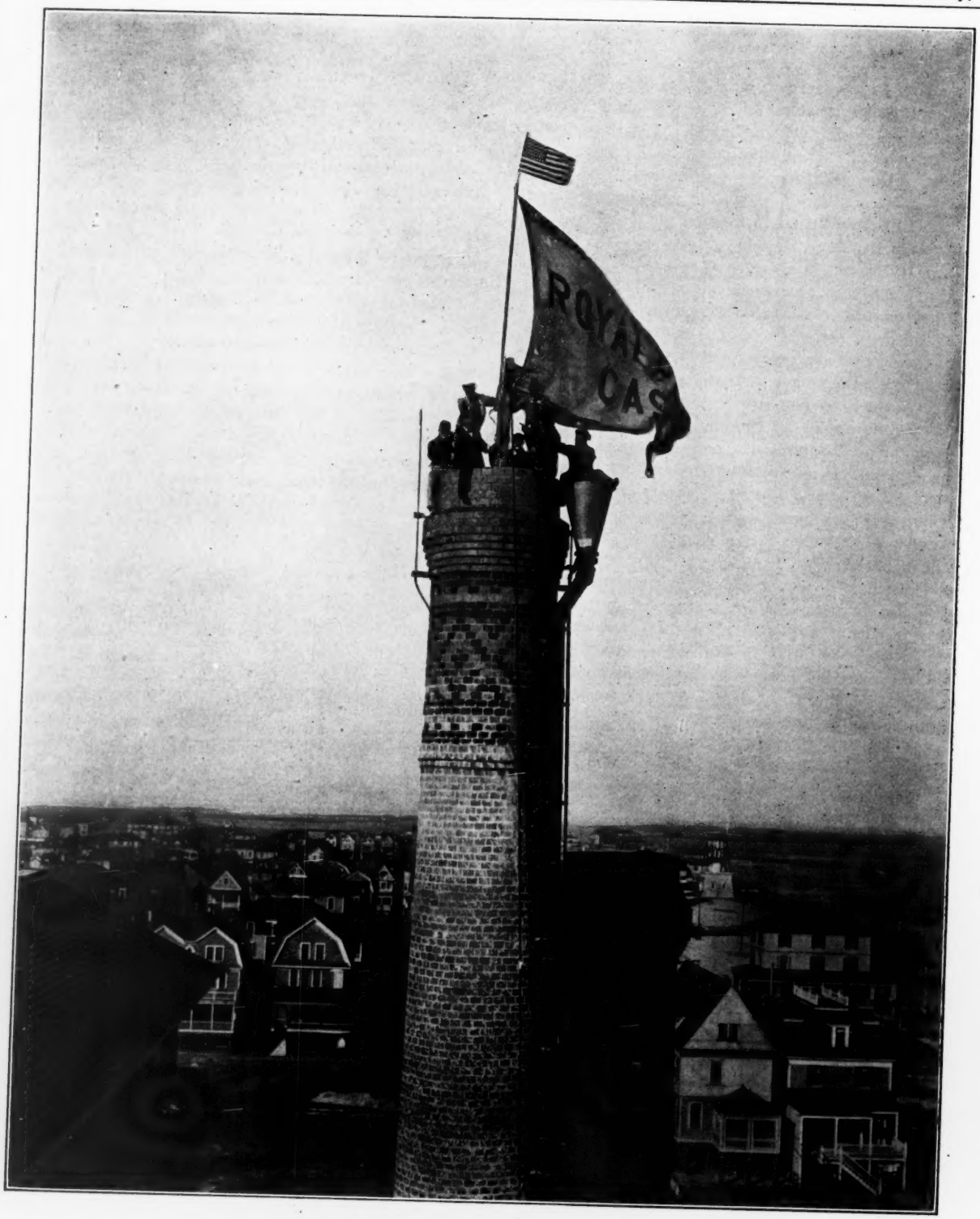
The velocity of the fan tips or circumference of the fan wheel which is necessary to produce a given velocity of flow through a properly shaped outlet within the capacity of the fan, is substantially equal to the velocity of the flow. If, therefore, the peripheral velocity of a given fan is known, the resulting pressure for the production of velocity through an outlet of proper size and shape may be readily calculated.

In selecting a fan the facts just presented should be borne in mind. It appears to be so simple to secure increased volume by running a given fan at higher speed, that the influence upon the power required is frequently overlooked. If the necessary amount of power is actually furnished, its expenditure will entail great loss in efficiency as compared with that required to operate a fan properly proportioned to the work.

In the design of a wheel to meet given requirements it is necessary to make its peripheral speed such as to create the desired pressure, and then to so proportion its width as to provide for the required air volume. Evidently, the velocity and corresponding pressure may be obtained either with a small wheel running at high speed or a large wheel running at low speed; but if the diameter of the wheel be taken too small, it may be impossible to adopt a width, within reasonable limits, which will permit of the passage of the necessary amount of air under the desired pressure. Under this condition it will be necessary to run the fan at higher speed in order to obtain the desired volume. But this results in raising the pressure above that desired, and in unnecessarily increasing the power required. On the other hand, if the wheel be made of excessive diameter, it will become more impracticable on account of its narrowness. Between these two extremes a diameter must be intelligently adopted that will give the best proportions for the specific work it is designed to do.

The actual work which a fan may accomplish must depend not only on its proportions, but upon the conditions of its operation and the resistance which are to be overcome. The simplest and most natural condition of operation is that in which the fan is operated without other resistance than that of the case; that is, with open inlet and outlet.

Air in excess of the amount necessary for perfect combustion tends to cool the furnace by abstracting heat from the gases of combustion.



Banquet on Chimney-Top 150 Feet in Air.

When the new 150-foot chimney at the Royal Palace Hotel, Atlantic City, N. J., was completed recently, the chief engineer of the hotel, Thomas A. Penderghast, decided to celebrate the event; so he built a platform inside top ring of the stack and invited his friends to partake of a banquet prepared for them there. No one could sample the menu unless he crawled up the side of the chimney to the lofty spread. Engineer Penderghast, who tips the scales at 206 pounds, snaked up the ascent like a lightweight steeple-jack and opened proceedings in orthodox battleship fashion by breaking a bottle of champagne over the nose of the big stack. Besides the chief, those having the affair in charge were Frank Wishman, assistant engineer; William Rich, Supt. Custodis Chimney Co.; Charles Wagner, iron erector; Hiram Mathis, builder, and C. W. Linderman.

ARITHMETIC FOR ENGINEERS

Some Principles of Division

By E. S. Hawkins.

Part III.

Since, as has already been explained, division is the reverse of multiplication, its terms are named to express just the opposite operations. The number to be divided is the dividend, the one which tells how many times it is to be divided is the divisor, and the result obtained by the division is called the quotient. All numbers may be divided, though some are divisible only by themselves and one. These are the Prime numbers. Those which cannot be divided equally by 2 are called odd numbers; all others are even.

It is well to keep the theory of multiples well in mind when using division, because a number is always divisible by any one of its multiples, or factors. Thus, 12 may be divided by 6 or 2, 3 or 4. These factors may be further used to facilitate the work if it is remembered that when several whole numbers containing a common factor are multiplied together, their product is divisible by the common factor. Thus, 4 is a factor of 36, and 48, $36 \times 48 = 1828$ and $1828 \div 4 = 457$. Or, again, any factor common to two numbers will divide their sum, or their difference.

The process of division, that awful "Long division," may be made clear if the following problem is studied a few minutes:

```
325 | 3989375 | 12275
      325
      ---
      739
      650
      ---
       893
       650
       ---
       2437
       2275
       ----
        1625
        1625
        ----
```

Here the divisor is set down to the left of the dividend, and separated from it by a vertical line. A horizontal line separates the dividend from the quotient. Beginning at the left of the dividend, point off enough figures to make a number larger than the divisor. In this problem it is 398 and it will be seen that 325 is contained in 398 only once. Place 1 in the first place in the quotient and multiply 325 by it. Place the product, 325, under the first three figures of the dividend and subtract to find the remainder. Besides this remainder, 73, write the next figure of the dividend, 9, making a new dividend 739, in which 325 is contained twice. Place 2 in the quotient and multiply the divisor by it as before. Subtract, draw down the next figure and repeat the process until the partial quotients are all found, when the example will be completed.

After a little practice it is quite unnecessary to write out the table for ordinary problems, but in very long divisions it is often used to save time. Another way of cutting it short is well illustrated by this same problem. Take the first figure in the divisor and see how many times it will be contained in the first figure of the dividend. Here this is 1, which is taken for the first figure of the quotient. Again, 3 goes into 7 twice. Take 2 for the second figure. This is often satisfactory, but sometimes it makes the number to be subtracted too large, in which case the next smaller number is taken instead.

When the divisor is of one figure only, it is necessary to set down only the terms of the problem and the result of the work is readily done in the mind. If it is desired to prove the division, multiply the quotient by the divisor or *vice versa*, and if the work is correct, the product is the same as the dividend.

In dividing a number by one followed by one or more ciphers, simply point off as many figures as there are ciphers. Thus, $94.579 \div 1{,}000 = 94.579$. If at the right of the dividend there are as many ciphers as at the right of the divisor, cut off the ciphers in the dividend and the division will be accomplished, thus $73{,}000 \div 1{,}000 = 73$.

Another short method works like this: Since $5 = 10 \div 2$, $25 = 100 \div 4$, and $125 = 1{,}000 \div 8$, it follows that when a number is to be divided by 5, 25, or 125, it may be more easily multiplied by 2, 4, or 8, and divided by 10, 100, or 1,000.

After these fundamental facts, necessary but tedious, comes the review of prime factors, cancellation, etc., terms sadly familiar to us all whose meaning and processes are often all too easily forgotten.

Prime numbers, as has been noticed, can be divided only by themselves and 1. They differ from odd numbers, therefore, as an odd number is one which cannot be divided by 2. All prime numbers are odd, but all odd numbers are not prime. As, for instance, 9 and 21, either of which may be divided by 3. A number is said to be prime to another when they have no common factor or divisor but 1. A divisor is common to numbers when it will divide all of them. The greatest common divisor is the largest number that will divide each of a series of numbers. The least common multiple is the least multiple found in each of a given set of numbers.

To find the factors of a number it is necessary to separate the number into multiples whose product will equal the number. Thus, the multiples of 36 are: $2 \times 3 \times 6$, or, $4 \times 3 \times 3$. When one number, as 5, is multiplied several times by itself, the product is called its Power. As, $5 \times 5 \times 5 = 125$. Here 125 is the Power of 5. The number of times that the multiplication is repeated is called the Degree of the Power. Thus, 3 is the degree of 125. The second power of a number is its Square. The third its Cube. If it is desired to express the power without the operation, write the degree as a small figure to the right a little above the number. 7 to the fourth power is written 7^4, and means $7 \times 7 \times 7 \times 7$.

A short method of operating when there are several terms in both dividend and divisor, is called cancellation. It is based on the theory of common factors. Suppose, for instance, that the fractions, $\frac{21}{4}, \frac{28}{7}, \frac{54}{5}, \frac{9}{42}, \frac{6}{45}$, are to be multiplied together,

the upper figures will be set down in succession with multiplication marks between each two, and the divisors will be set below them in the same way, thus:

$$\frac{21 \times 28 \times 54 \times 9 \times 6}{4 \times 7 \times 9 \times 42 \times 45} = 6$$

Since 9 is found in both the dividend and the divisor, it is crossed out of each. Then follows a dividing of figures above the line into those below and *vice versa*. Thus 4 goes into 28 seven times and the figure 7 is set down above the line, the figures 4 and 28 being crossed out at the same time. We now have the figure 7 on both sides of the line, so that the two figures may be crossed out. By continuing this process the result is found to be 6, which is the product of all the dividends divided by the product of all the divisors. The practical utility of this process becomes more apparent in dealing with large numbers.

SHAFT COUPLINGS

By E. H. Naylor.

While it is not often that anything is published on the above subject, yet as a rule, engineers of both large or small factories must be responsible for not only the engines and boilers of the plant, but the power transmission machinery throughout the entire establishment, and in this connection the engineer should be able to so understand shafting, couplings and hanger that he can give the proprietor or superintendent any intelligent information that he may desire on this subject.

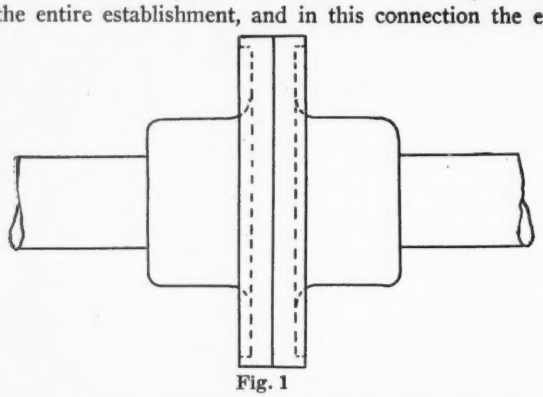


Fig. 1

Shaft couplings should be carefully selected and strict attention given to the conditions under which they must work. The load may be steady throughout the day or it may vary from no load to full load several times a minute. Heavy loads, being thrown off or on at frequent intervals, produce hard strains and this gives the most severe test of the coupling, so that if the proper one for the place has not been selected, signs of distress will soon make themselves known and if not followed up as soon as discovered, serious trouble and delay will result and the repairs will be more difficult to make.

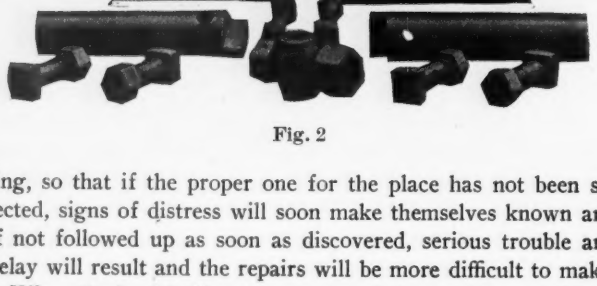


Fig. 2

When the load is about constant and the machinery is light, it is not very difficult to get the shafting and pulleys of right size, but when allowance has to be made for heavy intermittent work, the some good sound sense and judgment are necessary to successfully meet the requirements. Sudden heavy loads frequently twist the shafting off, the couplings standing the test, but there is but one coupling that the writer knows about which has stood such a test of holding until the shafting sheared off completely. This style is shown in Fig. 1, and is called the flange coupling.

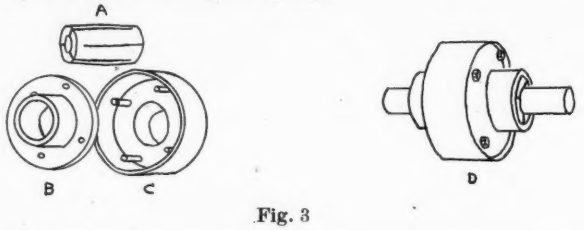


Fig. 3

The flange coupling or face coupling, as it is sometimes called, when properly constructed and keyed on to the shaft is the best and most reliable coupling made to withstand general abuse and shocks, although there are several kinds of clamp and compression couplings that might stand these strains, but with them there may be chances of trouble at any time.

The flange coupling has a neat and pleasing appearance and possesses durability and strength. There is one objection to this coupling and that is when factories are frequently enlarged and the positions of the workmen are constantly changing, as in shoe factories. In the latter case some of the workmen require power, while others are hand workmen; this makes it necessary, as the factory is enlarged, to keep moving the workmen along, so that the work can be kept moving in one straight line, as it does not pay to retrace any ground in the manufacture of shoes. This causes a lot of changing of shafting with every new addition, and the writer has had quite a number of these to deal with; and any one who has had to

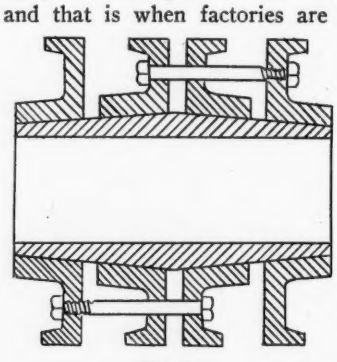


Fig. 4

remove one of those couplings from the end of the shaft will realize the amount of work required.

An arrangement known as a lock clamp coupling is shown in Fig. 2, the ends of the shaft being fitted for the same. This coupling is easily erected and a shaft can be taken down to permit the changing of pulleys and can be replaced without altering the position or alignment of the shaft. The durability and strength of this coupling have been proven by several years' use in almost every branch of manufacturing. The couplings are securely clamped to the shaft by means of six bolts; this compression on the shaft being depended upon, together with the ends of the shaft being halved and lapped, to hold the coupling and transmit the power. The bolt through the coupling and shaft is to prevent the shafting from working out of the coupling should the shaft get out of alignment. It it said that the tests made with this coupling have shown a holding power within 5 per cent. of a flange coupling. The writer has used this style coupling and has found that it can stand considerable abuse. He has about 40 of them in operation at the present time, and has had very little trouble with them, as they seldom work loose if properly placed on the shaft. They do not have as neat an appearance as flange or compression couplings, but are a good, durable coupling for most any branch of business.

The single compression style of coupling is shown in Fig. 3. A represents the sleeve; B and C, the sections of the outer shell; D shows the coupling fitted to the shaft. The sleeve is tapered from the middle to each end and has six slots running nearly its entire length, three from one end and three from the other end alternately. The outer shell has a bore tapering from the middle outward, the taper corresponding with the taper on the sleeve, the diameter of the bore being slightly less than the diameter on the sleeve. The outer shell is divided into two halves, the halves being drawn together with four bolts and nuts. When the halves of the shell are drawn together by tightening the nuts on the bolts, the pressure of the tapering bore on the tapering sleeve, which is compressible on account of its slots, causes the sleeve to grip the shaft. When in place the flanges extend beyond the nuts and the head of the bolts.

In taking down the coupling the nuts are removed from the bolts and the halves of the shell can be easily thrust apart by screwing the bolts into the threaded holes. This makes about one of the most complete and durable compression couplings made up to 2¾ inches. It is well proportioned, neat-appearing. They will stand some severe shocks and are well adapted to such plants as shoe factories. The ease with which they can be handled, moved and adjusted to run true is a point in their favor. The writer has about 60 of them in use and has never had one of them to slip on the shaft.

For an average all-round coupling I prefer Fig. 3, but for extremely heavy duty I will always specify the flange coupling keyed on. Fig. 4 represents a patent double compression flange coupling, constructed with four flanges instead of two, the alternate flanges being bolted together. This style has a large holding power for shafting of large diameter.

THE PULSOMETER STEAM PUMP

A Useful Arrangement for Low-Service Water-Raising Purposes

The pulsometer steam pump is an arrangement by means of which water can be raised by suction into the pump chamber by the condensation of the steam within it, after which it is forced into the delivery pipe by the pressure of a new supply of steam on the surface of the water. Two chambers are required to do this successfully, and the accompanying illustration represents a cross-section of a pulsometer which explains its construction.

This old idea of raising water by the condensation of steam and then forcing it to a further elevation by the direct pressure of steam on the surface of the water, originated with Captain Thomas Savery, who, in 1698, patented his famous engine, which was really nothing more than a sort of pump along which lines the present pulsometers are made.

As designed by Savery, it consisted of two closed vessels supplied with steam through valves at the top and provided with pipes through which the water could be drawn in and discharged. In operating, one vessel was filled with steam, the steam valve closed and a spray of cold water injected. The vacuum formed caused water to rise through the suction pipe, filling the vessel. The spray cock was then closed and steam let in, pressing upon the surface of the water and forcing it out through the discharge pipe. By means of hand regulation a continuous stream could be maintained from the two vessels.

In its original form, Savery's pulsometer found a useful field in pumping water from coal mines, where great need was felt for some form of mechanical pump which would take the place of manual labor or animal power. Its enormous consumption of steam, however, and its limited range of height through which it could force the water, caused it to be replaced by Newcomen's engine, which provided power in a more convenient form and allowed the piston type of pump to be used and developed.

The principle of the pulsometer pump was then practically abandoned for several hundred years, and it was not until 1872, when Charles H. Hall patented his pulsometer, that this form of pump was again used. Its principle is simply a modification of Savery's original idea, the improvement being chiefly due to the use of automatic steam valves in place of valves requiring a man to operate them. It is now no longer limited to small lifts, because higher steam pressures are available.

The construction of the pulsometer is shown in the accompanying diagram, Fig. 1. It consists of two bottle-shaped chambers, *PP*, joined together side by side, with tapering necks bent toward each other and surmounted by another casting in which the two passages unite in a common chamber. At the junction is a small ball, *C*, which oscillates with a slight rolling motion, thus closing either of the two chambers to the passage of steam from the supply pipe, which enters above. Water is drawn in through the bottom opening and passes through the

suction valves, *EE*, and into the triangular space, shown dotted, and finally is delivered through the vertical pipe. A foot valve in a separate casting below the pump prevents the return of the water in the suction pipe. *PP* are the pumping chambers. The circular passage, *S*, is in the front part of the casting and connects with the air chamber marked *A*. Near the top of each of the working chambers, *PP*, and the vacuum chamber, *A*, is a small tapped hole, into which is screwed a check valve. The check valves in the chambers, *AA*, allow a small quantity of air to be automatically admitted above the water and ahead of the steam, forming an air piston and preventing condensation. The check valve in chamber, *A*, admits air automatically and serves to cushion any pulsations of the water due to the alternate filling of each of the chambers, *PP*.

The operation of the pulsometer is as follows: The ball being at the entrance of the left-hand chamber, and the right-hand being full of water, steam enters, pressing on the surface of the water, and forcing it out through the discharge passage.

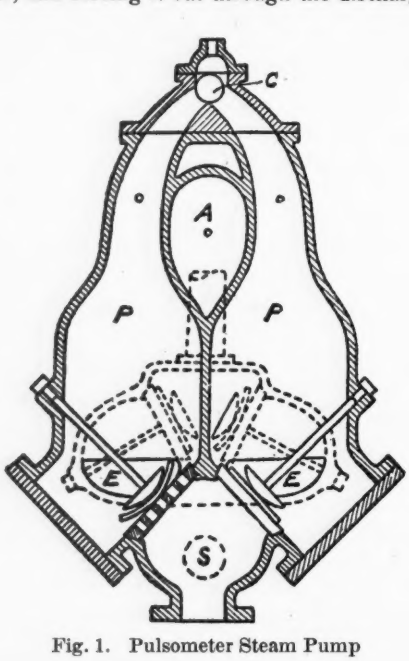


Fig. 1. Pulsometer Steam Pump

A rapid condensation of steam occurs from contact with the water and with the walls of the chamber, previously cooled by the water. When the water level has reached the horizontal edge of the discharge passage, a large volume of steam suddenly escapes and is at once condensed by the relatively cold water between the chamber and the discharge valve. The pressure in the chamber quickly decreases; it cannot be sustained by steam from the boiler, for, in accordance with the inventor's first specifications, the steam pipe is small. If, now, the pressure in the left chamber is equal, or nearly equal, to that in the right, friction caused by the rapid flow of steam past the ball will draw the ball over and close the right-hand chamber. Cut off from further supply, the steam, in contact with water, begins to condense; a jet of cold water from the discharge pipe spurts up through the injection tube, and by breaking into spray against the side of the steam space, completes the condensation. The partial vacuum produced brings water through the suction valve to fill the chamber; but at the same time the air valve admits a little air, which passes up ahead of the water and forms an elastic cushion to prevent the water from striking violently against the steam ball. The air chamber, *A*, is for the purpose of preventing water hammer in the suction pipe. Thus the pump pulsates regularly, steam being condensed and mingling with the water passes out at the discharge pipe, one chamber pumping while the other is filling, there being no external evidence that the pump is working except a slight clicking of the steam valve as it rolls between its seats.

This pulsating action is shown in Fig. 2, the curves being taken with 20-pound springs in the indicators, the three curves being made separately on the two pumping chambers and in the air chamber. Steam at a gauge pressure of 21 pounds was supplied, and a pressure of 12.4 pounds of water was obtained. The total lift was 33.1 feet, and the discharge was about 10 cubic feet per minute. *AA* is the atmospheric line; *VV*, the absolute vacuum line; *PP*, a line showing the water pressure on the discharge valves and the three curves show what is happening in all three of the chambers at any instant. The shaded areas above the discharge pressure line, *PP*, show when water is being forced through the discharge valves.

Regarding the relative efficiency of pulsometers when compared with piston steam pumps, tests show that a good duplex pump will give better results, but notwithstanding its wasteful use of steam, it is well qualified to compete with other pumps for some kinds of work. Its entire lack of moving parts or rubbing surfaces is a great advantage where it must stand

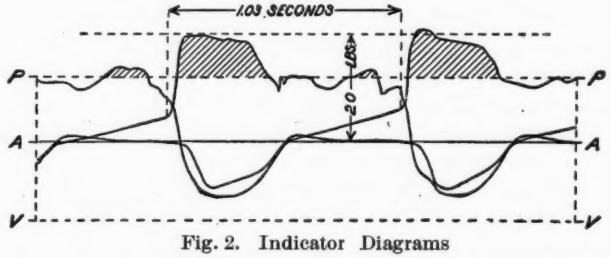


Fig. 2. Indicator Diagrams

rough usage or where the liquid to be pumped contains grit or sand. When equipped with the proper valves, it will successfully pump thick liquids or semi-fluids, such as heavy syrups and liquid mud. It is often used in chemical works and tanneries for pumping corrosive liquids. For temporary work in draining excavations or in emergencies, where a powerful pump must be put at work in a short time, the pulsometer is particularly adapted, since it requires no foundation and can be slung from a chain and supplied with steam through a flexible hose.

———o———

If a horizontal distributing steam main be used in a piping system, the feeder pipes from the boilers should rise out of its boiler with a long bend and enter the top of the main. All supply branches should take off, also, from the top of the main. The main should be drained from the bottom by special drain pipes, and the feeders should never be used for this purpose as water will not flow back against the velocity of the steam. When these distributing mains are short, it is best to anchor them in the middle and divide the expansion between the ends. When they are long place an expansion joint in the middle and anchor half-way between the joint and the ends.

APPLICATION OF MARIOTTE'S LAW

By Prof. A. Edward Rhodes.

It is sometimes necessary to make a gauge which shall indicate the pressure of compressed air. When such is the case the question often arises: How can the distances between graduations be found? The purpose of this article is not to describe a gauge of this kind in all its details, but simply to show how the application of "Mariotte's law" can be applied to finding the graduations on the scale.

The law of the compressibility of gases was discovered by Boyle in 1662, and afterward independently by Mariotte in 1679, so that the law is sometimes called "Boyle's law" and often "Mariotte's law." The law is as follows: The temperature remaining constant, the volume of a given quantity of gas varies inversely as the pressure; or, in other words, the greater the pressure the less the volume, and the less the pressure the greater the volume.

When air is compressed its temperature will be increased as well as the pressure, so that if great accuracy is desired, the temperature should be taken into account. For the sake of simplicity, however, to illustrate the application of Mariotte's law, the temperature will be neglected in the following calculations:

Suppose it is required to construct a scale which will indicate the amount of compression for every pound increase in pressure, the scale to be 30 inches long and the temperature constant during compression. Referring to the illustration, Fig. 1, let T represent a tube whose area is just one square inch and bored out perfectly true; P, a piston fitting accurately in the tube; C, an air-tight chamber; F, a fulcrum, and L, a lever working on the fulcrum F, the arms of the lever being of equal lengths; w, a weight to balance the weight of the piston and rod, and W, a weight to balance the pressure of air. The friction of the piston in the tube is assumed to be so small that it can be neglected without an appreciable error.

Now assume that the piston is placed in the tube in a position as shown, and perfectly counterbalanced, so that the distance between the top of the piston and top of the inside of tube is 30 inches. In placing the piston in this position the hole, H, in the top of the tube should be left open, and after the piston is in position close the hole, H, with the set screw shown. The space in the tube above the piston is now filled with air. Also assume that the air is being pumped out of the chamber, C; then in order to keep the piston in the position shown, the weight, W, must be placed in position, small at first and increased as the space in the chamber, C, approaches a vacuum. When a perfect vacuum has been obtained, the weight, W, will be found to be equal to 14.7 pounds, which, for the sake of simplicity, is often taken as 15 pounds.

The weight, W, indicates that the pressure of the air in the tube tends to press the piston into the chamber, C, with a force equal to 15 pounds, so that we have a column of air one square inch in area and 30 inches long exerting a pressure of 15 pounds. If then the piston is moved upward to within 15 inches of the top of the tube, so that the volume is compressed one-half, then, according to Mariotte's law, the pressure must be doubled; that is, it must be equal to 30 pounds. This pressure can be found by the simple rule of proportion, thus: 15 inches : 30 inches = 15 pounds : pressure in which the product of the two outside terms equals the product of the two inside terms or $(30 \times 15) \div 15$, equals the pressure of air in the tube.

If the piston be moved upward to within $7\frac{1}{2}$ inches of the top of the tube, the air is again compressed one-half, and therefore, according to the same law, the pressure must be 60 pounds. As before, this can be found from the proportion $7\frac{1}{2} : 30 = 15 :$ pressure, or

$$\frac{30 \times 15}{7\frac{1}{2}} = 60 \text{ pounds.}$$

In a similar manner the rue for finding the pressure when

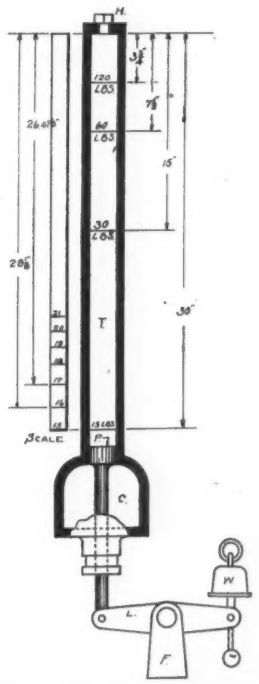


Fig. 1. Illustrating Mariotte's Law

the piston is at at any position in the tube can be expressed by the proportion, thus: The distance from the top of the tube to the top of the piston is to the length of scale in inches as one atmosphere is to the required pressure. Or, putting this in the shape of a formula, it becomes

$$\text{Press. required} = \frac{\text{Length of scale} \times \text{One Atmosphere}}{\text{Distance between top of tube and piston.}}$$

If the pressure is given, as in the above problem, the formula can be reversed so that the distance of the graduation from the top of the tube can be obtained thus:

$$\text{Distance between top of tube and piston} = \frac{\text{Length of scale} \times \text{one atmosphere}}{\text{Given Pressure.}}$$

Since the problem is to find the distances of the graduations from the top of the tube for every pound difference in pressure, we have for 16 pounds

$$\frac{30 \times 15}{16} = 28.125 \text{ inches}$$

which will be the distance of the first graduation, and the distance of the second graduation will be

$$\frac{30 \times 15}{17} = 26.47 \text{ inches}$$

and in a similar manner all the graduations on the scale are found.

A Little of Everything Concerning the Injector

Answers to Questions asked about this Type of Apparatus

By H. A. Cozzens.

The most simple apparatus for feeding boilers was invented by Henri Jacques Giffard. He called the device an injector and had it patented May 8, 1858. Giffard had an early education which most mostly technical and this, combined with his own ingenuity, amply fitted him for inventing a device which was doomed to startle the mechanical world.

His design of the injector body is carried out to this day, and the proportions of the nozzles have been varied little since his time. The invention was based entirely upon theory and on the first trial of the device the expectations of the inventor were carried out to the dot. As a testimonial of their interest in Giffard the Academy of Science in Paris awarded him the grand mechanical prize for 1859.

There are two main classes of injectors, namely: the automatic and the positive or double tube. The automatic injector is the device which has an overflow which opens and closes through the action of the injector itself. In this type of injector only one set of tubes are found. By the term "automatic" it is generally meant that the injector will immediately start when the water is turned on after the supply has been shut off and on repeatedly. As an example of this fact, a vessel at sea may be used. When the vessel rolls, the seacock is part of the time in the water and part of the time out, but whenever it strikes the water the injector resumes its work. Engineers like automatic injectors not only for the above-named reason, but because they cost less to operate, have fewer parts to wear, and are much more simple in construction, and last but not least, in the automatic injector, steam cannot blow back in the suction pipe.

The positive or double tube injector is the "old reliable." It has a mechanically opened and closed overflow. Instead of one set of tubes it has two, one for lifting the water and the other for forcing it into the boiler. I have explained the mode of action of one similar to the positive injector below. In this type of injector the figures generally accepted are that it will draw water from 2 to 12 feet according to size, but the water supply must be continuous and not hotter than 135° Fahrenheit for low pressures and 105° Fahrenheit for high pressures. If these temperatures are exceeded, the velocity of the steam is retarded too much.

Many different theories and principles of the injector's action are to be found, but the one which is generally accepted is as follows: The principle of the injector's action is that of induced currents. The velocity of an issuing jet of steam is many times greater than one of water under the same pressure. For the same reason that a rapidly moving body will draw articles in its path, steam passing through an injector forces water into the boiler.

What happens inside the injector is this: Steam enters through proportioned nozzles and is condensed on coming into contact with the water. The only velocity that the steam loses is due to the friction of the passages. A vacuum is formed in the injector by the condensation of the steam and this causes more water to rush into the injector through the suction pipe or intake. This water is carried on through the delivery pipe by the force of the condensed steam and is forced against the check valve which is raised and held open by the momentum of the water as it rushes into the boiler against the boiler pressure.

Another theory has come to light through the correspondence department of one of our engineering papers, and may be called the expansion theory, viz.: The steam enters through nozzles and on striking the water which is drawn up by the vacuum gives to it all of its heat units. The water is then expanded and thus forced into the boiler. This theory is condemned on the basis that fluid pressure is equal in all directions and the expanded water might just as well fall back through overflow or suction pipes.

A question is often asked concerning whether there is any vacuum in an injector when it once gets started. If the injector is non-lifting, there will probably be no vacuum formed in it after it is once started; but in a lifting injector the application is different, a partial vacuum must be kept in order that the pressure of the atmosphere may act on the supply and force the water up the suction pipe.

As to the use of compressed air in place of steam, I would say it is not advisable. In some makes of injectors compressed air could not take the place of steam owing to the construction of the injector. In the first place, air must necessarily enter the boiler as it is not condensed like steam. Now air is not very good to have in a boiler, as the oxygen combines with the acids often contained with feed water and causes rust and corrosion. Air in the boiler also plays havoc with the engine which is being run condensing, as sufficient vacuum cannot be obtained.

All the piping for injector connections should be as straight, short and free from turns as possible. When a turn is necessary, make it gradual and not short. When a lifting injector is used and more than 10 feet of suction pipe are needed, it is advisable to have the pipe one or two sizes larger than the corresponding branch of the injector. It is better to use new pipe for the injector, but if none can be procured, blow steam through the old pipe to see that it is not partially clogged up or rusted. Steam for an injector must be taken from the boiler direct and from the highest point of the boiler. Taking it from headers or other pipes is liable to cause wet steam which may

hinder the working of the injector. The suction pipe should be subject to the greatest care. It should be independent of any other connection to avoid the breaking of the suction of the injector. Great care must be taken to get the suction perfectly air-tight as the slightest leak will prevent the injector from working properly. Generally, feed water is piped to enter the boiler below the water level, but if an injector is used this is not so material as the feed water is always hot. The check valve in the delivery pipe should be placed as near the place where the pipe enters the boiler as possible. If the injector is used to force water through the heater a check valve should be placed between the injector and the heater. When the lift is long it is best to place a foot valve near the lower end of the suction pipe. When the injector is stopped the water will then be held in place. Steam is saved then when the injector is started as it would be necessary to exhaust the air in the pipe, and you have the satisfaction of the injector starting immediately.

Some of the principal causes of the failure of injectors to work are as follows: Leaking pipes are apt to cause an injector to break; if a leak should occur in the suction pipe air would be drawn in such quantities that the water would not rise to the proper height in the suction pipe. Small air leaks may be stopped by wrapping a wet cloth around the pipe. If the leak is not large enough to stop the flow of the water it will keep the water from opening the check valve by causing air and water to mix. Leaks may occur outside the suction pipe, but most generally are found around the packing about the suction pipe valves.

The accumulation of scale in the tubes is another cause for the failure of injectors to work. When soda is used to soften the feed water and is forced through the injector it often clogs up the instrument. Just as soon as the water is heated scale is formed so it cannot be overcome. The only remedy for this is to clean out the tubes and delivery pipe.

The temperature of the feed water has much to do with the proper running of the injector. It must be low enough to permit the condensing of all the steam delivered from the nozzle. If steam should escape it will prevent the water from opening the check valve.

The injector is not equal to a well-built pump for boiler feeding when viewed as economy. When a plant is equipped without a feed-water heater, the injector is superior to the pump as it heats the water which it forces into the boiler. The injector is used in power plants generally only as an emergency boiler feeder. Its use on the locomotive is best known and one rarely sees an engine with the old-time gear pump.

Electric-Driven Water Supply Plants

By Frank C. Perkins.

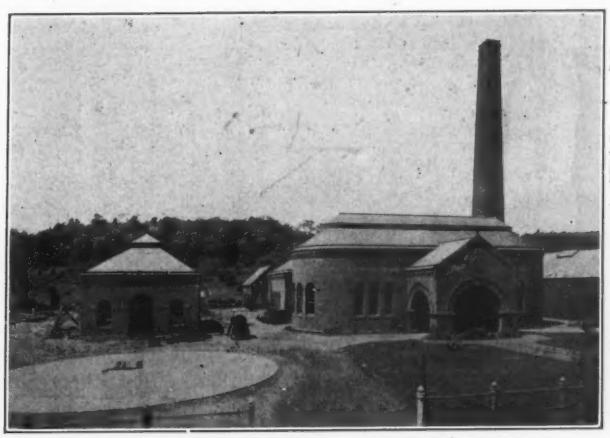
For water supply plants in large municipalities where electric current is available at low prices from hydro-electric power stations, electrically operated centrifugal pumps can be utilized to great advantage. This is particularly true where large reservoirs are available, into which water can be pumped during the day, the capacity of the electric pumps being greater than the normal demand, and the extra current purchased from the power company for 24-hour service being utilized for electric lighting service at night. This extra current will therefore be furnished at an exceedingly low rate as there is an even load line for the 24-hour service, usually the day demand for water being at least 25 per cent. greater than at night.

Centrifugal pumps of the latest design are now being utilized extensively both with horizontal and vertical shafts operated by alternating current motors from power transmission lines, having efficiencies as high as from 70 to 80 per cent. for the centrifugal pumps, making the same particularly desirable for water works service in competition with even the highest grade and most efficient triple expansion steam pumping plants.

In case the current can be purchased at low rates from power transmission companies, electrically operated municipal power stations are very desirable on account of the low cost of installation as compared with steam pumping plants. Low prices for power should be granted, as this form of load is particularly desirable, being utilized during the entire twenty-four hours.

The rate of charge at Schenectady is $6.50 per million gallons pumped, or $39 per day for a minimum of 6 million gallons, the same rate being charged per million gallons in excess of this amount. It is stated that the quantity used at Schenectady varies from five to seven million gallons per day.

It is necessary that the pumps should be operated at their maximum output in order to obtain the highest efficiency, and it is to the interest of the municipality that the amount of water pumped be in excess of the minimum pumpage in order that payment be not made for more current than is actually supplied by the power company.



Schenectady City Water Works

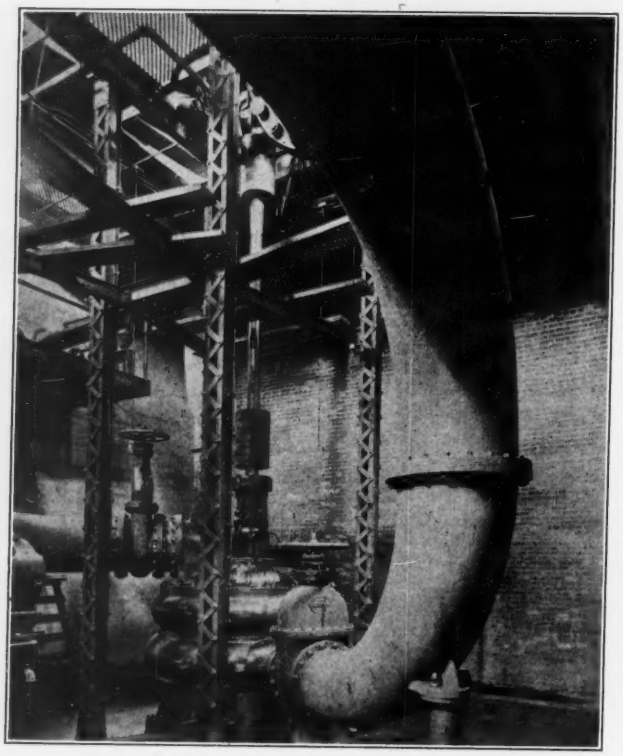
At Buffalo a similar electric pump to those installed at the Schenectady water works has been in operation for more than a year, delivering over 25 million gallons of water per day against a head of 189 to 192 feet, this pump being double the power of the Schenectady pump and designed to operate at 200 feet head.

The rate charged at Buffalo by the Cataract Power & Con-

duit Company is $4.50 per million gallons pumped at 200 feet head, this being lower than the head at Schenectady. In order to obtain this rate, 775 million gallons must be pumped per month, and in case only half of the amount is pumped, or the full capacity for 15 days, the rate charged is $9 per million gallons. It will therefore be noted that in order to compare favorably with the cost of pumping by steam the pumps must be operated at their full capacity and at the full head, as no reduction is made if the pumps operate at lower than the full head.

If the current is purchased by the municipality at a definite low rate per electrical horse power 24-hour service instead of a rate per million gallons pumped, the excessive current at night, whether from operating the pumps at lower head or due to smaller pumpage can be utilized for electric lighting, thus saving this waste of current, the lighting being obtained at proportionately low rates.

The accompanying illustrations show the electric pumping



800 H. P., 550 Volt, 40 Cycle Induction Motor operating 2-Stage Vertical Turbine

plant at Schenectady, the current for operating the plant being supplied from the Dock Street sub-station of the Schenectady Illuminating Company, two transmission lines of 10,000 volts pressure being utilized. The current is purchased by the Schenectady Distributing Company from the Hudson River Power Company, and is transmitted by overhead power transmission lines at 30,000 volts pressure from the hydro-electric plants at Spiers Falls and Mechanicsville, N. Y., a distance of from 30 to 35 miles northwest of Schenectady.

The electric centrifugal pumps in the Schenectady pumping station are of the Worthington type driven by General Electric induction motors operating at a speed of 800 revolutions per minute. These motors have a capacity of 800 horse power each and are supplied with a three-phase current of 500 volts pressure and having a frequency of 40 periods per second. The vertical motors are mounted on the upper floor together with the switchboard and air blast step-down transformers, while the vertical shaft pumps are located on the floor below, oil being supplied at a pressure of 6.6 atmospheres for lubricating the bearings.

The necessary power for supplying this oil under pressure to the thrust bearings of these two vertical electric pumps at Schenectady is supplied by two three-cylinder Knowles oil pumps each driven by a three horse power induction motor. There is also in this plant a two-cylinder, 9″ x 7″ air pump directly coupled to a five horse power induction motor.

There is every reason to believe that electric pumping for city water works service will be extensively used in the future, the first cost of installation being extremely low, and where current can be obtained at low rates, this will very largely offset the usual low efficiency of the centrifugal pump as compared with the highly efficient triple expansion steam pump, while greater efficiency is obtainable than many of the centrifugal pumps now in operation by the careful design of the impellers and guides.

There are many advantages to be gained by a combination of water pumping plants, large reservoirs and hydro-electric plants, and transmission lines and in many localities in Europe this plant is utilized.

There are many electric water power stations supplying light and power service, which have no reserve available and in winter are at a great disadvantage. These plants are unable to supply sufficient current for light and power during the evening or morning hours, or during certain hours of high peak load, while during other hours in the day or night all the daily output of the plant is not used. This is also true of the purchase of hydro-electric power where an even load line cannot be obtained.

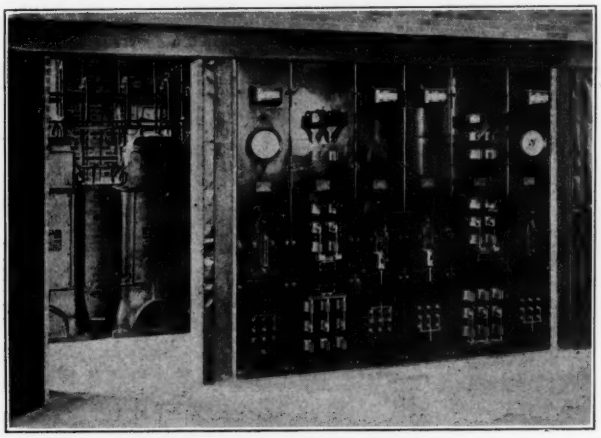
This problem was solved in one plant in the following manner: A combined set was installed which included on the same shaft a Centrifugal High Lift pump, a turbine and a motor generator. A large reservoir was available of 12,000 cubic meters capacity located on a mountain near the pump house, the head available being 1,000 feet.

An impact turbine of 1,200 horse power capacity was used, operating at 1,200 revolutions per minute. During the heavy load period, when there is the greatest demand for current from the central station, this turbine drives the motor-generator by the water in the reservoir, the electrical set working as an alternator in parallel with and helping out the alternating current generators at the main central station.

This motor generator, mounted on the same shaft as the pump and turbine, supplies a two-phase alternating-current of 5,250 volts with a frequency of 40 periods per second, taking from 1,000 horse power to 1,200 horse power of power from the turbine supplied by the reservoir, which acts as a great storage battery.

Now, during the period of light load, when the peak is off and there is plenty of current available at the main central station, the centrifugal pump which is of the high lift four-stage type, is set to work driven by the motor-generator acting in this case as a motor. It is stated that the normal delivery of the pump is 85 gallons per second against a head of 1,000 feet as it raises the water to the reservoir, taking it from the River

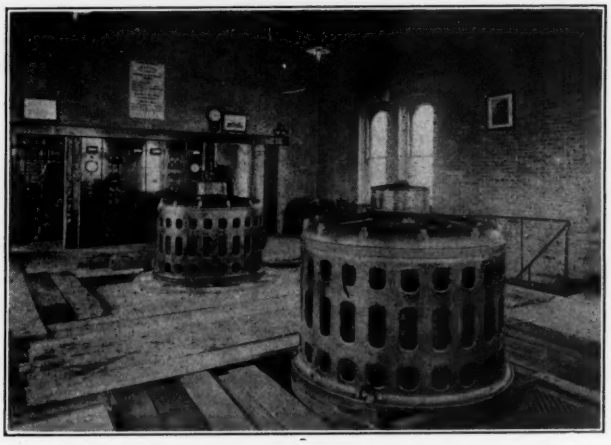
Aare. In this way the surplus current from the main station is used up, giving the plant a very even load line which is particularly desired. This pump is said to have given an efficiency of 76 per cent. and is capable of standing a heavy overload without trouble. All of the three machines, the pump, turbine and electric motor-generator, are mounted on the same bed



Switchboard installed at Schenectady City Water Works

plate or base, the pump having two bearings, one being a collar bearing, while a coupling is used between the pump and the electrical machine, which can be disconnected while running.

The pump and its suction pipe are filled by opening a by-pass valve, in starting the same, when a surplus of current is available at the electric power station, the minimum demand for energy existing on the light and power service wires in the city. Then the coupling between the pump and the electric motor-generator is engaged and the turbine is started up in order to get the entire unit under full speed. As soon as syn-



Vertical Shaft Induction Motors driving 1,200,000 Gallon Centrifugal Pumps

chronism is obtained and the motor-generator is taking current from the station electric mains, the turbine is shut off as the electric set is then working as a synchronous motor, and the pump gate valve to the delivery pipe is opened, the water being raised to the reservoir as long as light load continues at the main central station.

Electric power is now being utilized very largely in the West for electric pumping, for irrigation purposes, and also on the Nile in Egypt, while for fire service and for general city water supply electric driven centrifugal pumps are being extensively used with great satisfaction, particularly where electric power is available at low rates from transmission lines supplied by hydro-electric power stations.

At the City Water Works, at Geneva, a 1,000 horse power electric centrifugal pump is installed with two impellers 40 inches in diameter and delivering 22.5 cubic meters of water per minute against a head of 140 meters. This is one of the largest electric centrifugal pumps in operation even at the present time, the speed of operation being 450 revolutions per minute.

Near Frankfort-on-the-Main, Germany, an electric water works plant is equipped at Goldstein with three Sulzer High Lift electric pumps operating at a speed of 670 revolutions per minute, these horizontal shaft pumps taking 110 horse power each and delivering 5.5 cubic meters of water per minute against a head of 65 meters.

There are three electric pumping stations at Milan, Italy, all equipped with horizontal shaft centrifugal pumps driven by alternating current motors, directly connected, and supplied with current from the Societa Edison Station. There are 45 pipe wells driven at a number of points in the city of Milan, and the water is conducted from these wells to the suction air chests. The suction height is often 27 feet and the pumps raise the water without difficulty, after being freed of air.

In one station the pump is located directly over the well, pumping the water directly from it, while the other station has two electric pumps operating at 820 revolutions per minute and delivering 3.6 cubic meters of water each, against a head of 57 meters.

At the largest pumping plant in Milan there are four electric centrifugal pumps of the same capacity as those mentioned above, delivering the water into a common pipe, although all work independently. Another station under construction will have three pumps of larger output, supplying 6 cubic meters of water per minute against a head of 925 revolutions per minute.

The High Power centrifugal pumps at the water works station at the First Nile Cataract below Assaun, at Kom-Ombo, in Egypt, are used for irrigation purposes, the head being very low, as at this point the river Nile varies about 10 meters. The maximum height to which these pumps raise the water is 75 feet and single impeller pumps are used with spiral casings. These pumps are very large, however, taking 1,250 horse power each, and at a speed of 110 revolutions per minute deliver 200 cubic meters of water per minute, with the very high efficiency of over 80 per cent.

At Khoderat, in Upper Egypt, there is another irrigation pumping station using centrifugal pumps having a total efficiency of 71.25 per cent., each pump taking 450 horse power and delivering 175 cubic meters per minute against a head of 9 meters, the speed being 120 revolutions per minute.

On Saturday morning, December 22, shortly after the five o'clock shut down, a 400 horse power Buckeye compound engine was wrecked in the Wabash Portland Cement Co.'s plant at Stroh, Indiana. The heads of both cylinders were blown off and the engine stripped completely. Very fortunately no one was injured and no damage was done to the building. The plant was about to shut down, having had a very prosperous run of nine months.

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CONTENTS.

Some Principles of Direct Currents..... 3
Rotary Converters for Railway Service..... 5
Factors Affecting Compressor Capacities and Efficiencies... 7
Fan Blowers 9
Banquet on Chimney Top.....10
Arithmetic for Engineers—Part III.....11
Shaft Couplings 12
The Pulsometer Steam Pump.....13
Application of Mariotte's Law.....15
A Little of Everything Concerning the Injector.....16
Electric Driven Water Supply Plants.....17
Editorials 20-21
Letters from Engineers:
Overhaul Steam Chest for Pump Trouble.....22
Improvement in Radiator Drip Connections.....22
Twenty-Six Years an Engineer.....22
Michigan State License Law Needed.....22
Two Methods of Purifying Sulphuric Acid.....23
The "Old Man" Gives Some Pointers about Setting Piston Valves 23
Favors Massachusetts License Laws.....25
Lifting Water 26
Pump Trouble. Stuffing-Boxes should be made Deeper..26
Gas Engine Troubles.....27
Sarcastic Information Not Wanted.....27
Calculations for 2,000 H. P. Engine.....28
Questions and Answers 30-32
New Power Plant Equipment.....33-34
Book Reviews 34-35

Efficient Incandescent Lamps.

The greatest advance in the utilization of electricity during the past year has been in the direction of the increase of the amount of illumination per unit of power expended. The advance along this line has been so rapid that even those in the closest touch with electrical matters cannot keep track of the various improvements in incandescent and arc lamps which have been made recently.

When the tantalum incandescent lamp was first introduced in the beginning of 1906, great things were claimed for it and it was supposed that it would rapidly replace the old carbon filament lamp. It has done so on many direct current circuits, but its life on alternating currents is so short as to forbid its use.

The metallized filament lamp is now being made by a number of large manufacturers and has been in great demand, as it gives a higher candle power and higher efficiency than the old style carbon filament lamps, but not nearly so high in either respect as the tantalum lamp.

Another type of lamp about which very little is yet known is the tungsten lamp which, according to the best authorities, will revolutionize the electric lighting industry within the next few years. It is said that the tungsten incandescent lamp gives an efficiency nearly three times that of the carbon filament lamp of today, and as its life seems to be favorable, its success is assured if these predictions and experiments hold true.

The helion incandescent lamp is another newcomer in the lighting field which promises a comparatively long life with good efficiency. The filament is made with a carbon base on which there is a deposit composed largely of silicon. The light is extremely white and will give a candle power per watt of electrical energy expended, its life ranging from 485 to 1,270 hours on the few lamps which have thus far been tested.

In the arc lighting field, the mercury arc lamp and the magnetite lamp have made small inroads on the carbon lamp, although they are of much greater efficiency, but the probable reason why these newer lamps have not come into wider use is because, if the high candle power, high efficiency vacuum incandescent lamp becomes a commercial success in every respect, these lamps will take the place of the ordinary carbon arc lamps. The advantages of the exhausted bulb lamp are obvious, as they are cleanly, need no attention and they are not subjected to the ills which an arc lamp is heir to.

With the new high efficient lamps have come higher candle powers, and as the more light a consumer gets the more he wants, this will probably mean, not a lower ampere load on the dynamo, but a greater increase unit of illumination when incandescent lamps are used.

The Use of Fire-Brick Arches.

There seems to be a wide difference of opinion as to the propriety and efficiency of using a fire-arch above the grate in order to secure more perfect combustion of bituminous coal and thus prevent the formation of smoke. One of the objects aimed at is the production of high temperature which is obtained because the fire-brick or fire-clay tile, out of which it is built, has a large capacity for absorbing and storing heat.

When a hand-fire furnace is equipped either with an arch or over the grate, above the bridge wall or in the combustion

chamber, it is claimed that not only is the heat radiated almost unbearable for the fireman, but, as coal contains more or less foreign matter, the heat of the fire-box is so high that this foreign matter fuses into a clinker before the carbon or coke part of the coal, which burns slowly, is consumed. A portion of the unconsumed carbon fuses in with the clinker and is so much fuel lost. This means lost fuel, lost efficiency, increased labor and rapid deterioration of the grate-bars. It is also claimed that much efficiency is lost by radiation through the boiler front, and that this excess heat is very injurious to the fire-door liners and all metal work about the boiler front. Another objection which is entered against the fire-arch is the expansion and contraction which it undergoes, ofttimes injuring the side walls of the boiler setting which supports it. A "Dutch oven" is also said to have the same objections against it as a fire-brick arch.

With a boiler equipped with a chain-grate stoker or a stoker of similar design, it is claimed that the attainment of a perfect and smokeless combustion is secured by a tile roof. The effect of the presence of this tile roof is to prevent the flow of unburned gases among the surfaces of the boiler, and to insure that they travel a considerable distance before the heating surface is reached, during which time these gases and the air present therewith may become sufficiently mixed together to insure perfect combustion. There are many expert engineers who recommend the use of the tile roof or fire-brick arch, especially in connection with mechanical stokers, and without a doubt they are practically smoke-proof. In connection with these mechanically fixed furnaces, the objection that the heat thrown out is unbearable to the fireman, of course, does not hold; but the objection to the raw coal fusing with the clinker still holds good unless the stoker is properly designed.

The point is this: While the fire-brick or tile-furnace arch will prevent smoke, there is likely to be much unconsumed carbon lost in the ash. There are many cases where this arrangement must be used; but care should be taken to investigate its advantages and disadvantages before installation. Too often the use of fire-brick in the furnace is considered a cure-all for all furnace diseases.

Disturbing Motor Loads.

On all commercial lighting circuits, it is the object to maintain a steady voltage so that there will not be any variation in the candle power of the lamps which will cause annoyance to the consumer. This would be comparatively simple were it not for the motor load which all electric companies are striving to increase, as it is the best paying load usually on the circuits. As there is no such thing as either a direct or alternating current motor which will not affect the lighting service, steps must be taken to arrange the distributing system so that the motor load will not noticeably disturb the regulation of the lamps.

If the system be a large one, the motor load, if composed of numerous small units or of large units having steady loads, will be fairly uniform, and thus even a heavy motor load will give very little trouble with a properly designed system of distribution, the load being taken, in the case of the alternating current system, from the secondary mains. The troubles most generally encountered are a number of induction motors running lightly loaded, large motors running under variable load, motors with bad power factors carried by overloaded transformers and the overlapping of heavy lighting and motor loads.

When a large number of induction motors run under light load, they will run on the leading phase, and drop the other phases; if this happens, it causes the one phase to be heavily loaded while the other phases are lightly loaded, resulting in a decrease of voltage on the one phase and an increase in the others. In the case of large motors running under variable load, it will result in a fluctuation of voltage which may not be permissible. To better such difficulty, two methods are available: first, use a hand regulator in connection with the reducing transformers or, if the motor load is important, the lighting load may be carried by a dynamo driven by a synchronous motor.

When the power factor of a circuit becomes low, owing to a large inductive load, the introduction of a synchronous motor will aid the power factor and regulation of the load. It constitutes a load that is substantially non-inductive, and takes current almost exactly in proportion to its work. It acts the same as an electrical condenser in compensating for inductances in other parts of the circuits, thus tending to raise the general power factor to unity. Its principal objection is that it is not self-starting, and it requires the constant use of a continuous current exciter. For these reasons it is usual to only employ synchronous motors in sub-stations or where the employees of the lighting system can start and stop them, because if they should be started and stopped by irresponsible parties, dire results may be expected to the transmission system and machinery.

When attempts are made to furnish all classes of loads from a common line, it wil be found that many intricate and puzzling problems must be met and special treatment in regard to regulation must be used to maintain satisfactory lighting circuits.

A new form of boiler tube which has recently been introduced is known as the "spellerized" steel tube. Its particular advantage is that, because of a mechanical treatment of the interior and exterior of the tube, corrosion is greatly retarded. It is said that should the tube be dipped endwise in any corroding fluid, such as acid, the inner body of the metal would be eaten away, leaving the "spellerized" inner and outer coating intact. Tests have shown that where other forms of boiler tubes have been corroded with certain kinds of feed water, this make of tube has resisted its action.

There are various terms used in the discussion of the fundamental principles of the steam and heat engine which, generally speaking, have only a vague significance to the average engineer. While these principles and terms may never be of any value in the running and operating of the plant, yet the theory of the steam engine represents the efforts of the most learned men in the engineering profession to explain why the engine gives a certain efficiency and upon what lines this efficiency can be increased.

The theory which discusses the relation between heat and work is called thermo-dynamics, and it forms the centre about which the rational improvement of a prime mover must revolve. With a knowledge of this science, the wonderful discoveries of heat engines which are weekly described in the Sunday newspapers are easily shown to be mere bubbles, which, when examined, are found to contain nothing within.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

Overhaul Steam Chest for Pump Trouble.

EDITOR THE PRACTICAL ENGINEER:

I think that J. R.'s letter about pump troubles, in the January issue, settles the whole trouble. You will find when all auxiliary pistons and supplementary slide valves on pumps like the Deane start to wear out, that the steam leaks, so that it is impossible for the supplementary slide valve to exhaust the one end of the auxiliary piston, and the result is that the other end contains just enough steam to equalize the auxiliary piston and keep it about mid-way. The pump rod is supposed to move the auxiliary piston by striking the tappet and move the whole valve motion in the steam chest in case the supplementary slide valve failed to start the auxiliary piston; but this is hard on the valve stem.

The best way when pumps work badly like this, is to bore out the auxiliary cylinder, cast a new auxiliary piston so that it will be light and still strong enough to do the work; it should also be a nice oil fit. Slide valves should be nicely faced off with scraper and surface plate. The valve stems should be nice and true with no shoulders on them, and the same with the piston rod.

The Deane or any other pump when in good order will run like a clock. There are some engineers who, when they try to prime a pump, don't know that the object in doing so is to seal the valves and piston so that the air from the outside cannot get back into the suction pipe again. If you don't have a large opening for the release of the air on the discharge side of the pump at every stroke, the air only re-expands in the cylinder and keeps the air in the suction pipe. You will find for a 6-inch piston a ¾-inch valve will not be too large; the larger the pump, the larger should be the outlet for air. Let the water that comes out of the valve return to the supply.

St. Louis, Mo. F. J. W.

Improvements for Radiator Drip Connections.

EDITOR THE PRACTICAL ENGINEER:

I have noted the fine spun theory advanced by "Scotty" on page 24 of the January issue, concerning faults that ought to appear in my improved drip connections. The only trouble with his theory is that it don't work in practice, which is a rather serious defect. The improved arrangement of piping that I presented has worked quietly and well ever since it was installed, hence his fears are groundless.

These connections are located in a large building forming part of my plant. It is three stories high with a basement under a portion of it, in which there are several radiators, therefore it is impractical to carry a water line as he suggests, as some of these are only a few inches above the receiver into which all water resulting from condensation gravitates and is taken out by a pump that returns it to the boilers.

Furthermore, there is not the least necessity for such a water line, as all three floors are fitted with connections which are practically the same as the dotted lines in my original illustration show. I have supplied this building with steam heat for 12 years without any of the trouble that "Scotty" anticipates, therefore I do not fear it now. The steam and drip connections that I described were put in comparatively recently when a few changes were made in some of the rooms in this building, and this is the only part of the entire system that has given any trouble.

Perhaps "Scotty" overlooked the fact that I was telling about changes I had made, consequently was not advancing a theory concerning what ought to be done.

I have another three-story building, a great deal larger, in which I carry a water line in the basement. It works no better than the other, which has none, but both are practically noiseless.

New Haven, Conn. W. H. WAKEMAN.

Twenty-six Years an Engineer but can still Learn.

EDITOR THE PRACTICAL ENGINEER:

I notice in the January issue of your paper, a communication from "Golden West." He takes J. C. Scott to task because Mr. Scott says he has learned some things from ads. and catalogues. I have learned some valuable things from catalogues and I am not ashamed to state that I can learn yet, although I have been 26 years at engineering and I have spent some 6 years in the shop; but I do not think it is right for any person to write in the bombastic manner and call other people's attention to their short-comings as "Golden West" has done to Scott and M. L. S. Where did "Golden West" obtain all his supposed superior knowledge he is so willing to parade? He mentions a number of valuable authors, but there is knowledge contained in catalogues on some subjects that is just as reliable. About burning oil, M. L. S. made some statements about consumption of oil which "Golden West" contradicts. Where did he get his information? Probably from some book or catalogue. I suppose he is one of those fellows who can figure the weight of a feather or a mosquito.

Cleveland, O. J. T.

Michigan State License Law Needed. Kerosene in Boilers Makes Scale Harder.

EDITOR THE PRACTICAL ENGINEER:

I want to say that I heartily agree with T. F. S., in the December issue, in all that he says with regard to license laws and questions asked by some examining boards. I believe there are many good, practical engineers who are more competent to operate a steam plant of any size than the designing engineer or the man who can answer some of those questions. I also know that it is possible for a man to hold a first-class license under our city (Detroit) ordinance and yet fail to make good in a 150 horse power plant. I have known of persons, under a former administration, who coudn't tell a pump from a feed-water heater; but I believe the present examiner aims to give a good, practical examination to all who apply, without fear or favor.

What we want in the State of Michigan is a good State law which will provide for the examining of engineers only, leaving the boiler inspection to the boiler insurance companies.

In the November issue Mr. Kavanagh, in his article on the "Care and Management of Horizontal Tubular Boilers", recommends the use of kerosene oil as a scale remover. I don't agree with him there. It may be all right in some cases, but my experience with it has not been a success. I have used kerosene alone and in connection with sal-soda, and about the only result I found was that it made the scale harder than ever. Maybe with different water better results can be obtained. A boiler inspector once told me that he could tell where kerosene was used by the hardness of the scale. I get good results by using nothing more than common sal-soda.

Detroit, Mich. G. H. C.

Two Methods of Purifying Sulphuric Acid.

EDITOR THE PRACTICAL ENGINEER:

I enclose some words about the methods to purify sulphuric acid when it is impossible to get it chemically pure. They are taken from personal notes written from experience:

The distilled acid used for storage batteries should be chemically pure or at least be without traces of chlorine, nitrogen (especially in composition with oxygen) and metals, which when in contact with the lead in the cells act as electo-negative, as, for instance, copper, arsenic and especially platinum, of which a trace of one part in 2,000,000 parts of solution may be the cause of discharge at open circuit. The copper salts, too, if not mixed with other salts, are as dangerous as platinum.

If impossible to get the acid in the above pure condition, the purification could be performed in the plant before using the liquid in filling the cells. Two methods may be used for this purpose, one method being as follows:

Mix with the acid a solution of 2 per cent. of sulphydrate of barium, $Ba(SH)_2$, in proportion of a quarter of a gallon to 25 gallons of the diluted acid in this manner: Take a little glass pipe as shown in sketch, and plunge it with the point *a*

Glass Pipe Used for Purifying Acid

in the solution of the said sulphydrate of barium and aspire it from the opening *b* until the pipe shall be almost filled; close the opening *b* with the thumb, take out the pipe from the solution and plunge it in the sulphuric acid, raising the thumb at short intervals so that the liquid will flow out little by little; at the same time be careful to shake the pipe in order to have a good mixture between the two liquids, and for the same reason another person should blow in the liquid at short intervals by means of a rubber hose inserted to touch the bottom of the tube where the operation is performed, helping in that way to make a perfect mixture. The sulphuric acid will grow torpid, sometimes a brown color.

Finished this work, let the liquid stand covered for two days in order to allow it to clear. If the acid has the fetid character and has the odor of sulphide of hydrogen, then the acid is good for the battery and can be poured in the cells by a rubber syphon. In case the acid has lost its characteristic odor, the operation should be performed again.

An easier method is to mix with the acid at 66° B, a little quantity of olive oil, about 3 or 4 cubic inches for every quarter of a gallon of liquid. After 12 hours of rest, dilute the acid to the needed density. The solution should then be of a milky color, but, after cooling, it becomes clear, while all the impurities come to float on the surface under the form of scum, which can be taken out with a piece of thick paper—don't for any reason use a spoon of metal or wood. A good spoon can be made with a little sheet of perfectly clean lead.

The water used for the solution must be absolutely pure; if it is impossible to obtain distilled water, a good plan, economical, too, is to collect rain water in lead-sheathed tubs, or boil ordinary water in order to precipitate a part of the carbonate of lime which is in solution with the water; at least take the water from a common main after a large quantity has flowed out.

In pouring or decanting acid or water, use rubber syphon and don't shake the vessel.

Newark, N. J. C. P.

"The Old Man" Gives Some Pointers about Setting Piston Valves.

EDITOR THE PRACTICAL ENGINEER:

"Gentlemen, I think we have come to a point in your course of instruction that a few practical hints will be appreciated and better understood by you now than they would have been earlier in the season."

The above is what we heard, one evening, when the class opened. The class consisted of fifteen aspiring young engineers, and the speaker was the "Old Man", who was giving us a course of instruction on steam and the steam engine, which he was well able to do, not only by his many experiences in all parts of the world, but by his early theoretical training, he being a graduate of the College of Science and Arts, London, and also the possessor of Chief Engineers' certificates granted him by three Governments, namely: British, American and Japanese, and was still under 35 years of age; so you will understand that "Old Man" was hardly applicable from point of age, but from respect and appreciation of his knowledge and experience, which, being always combined with such unfailing good nature that the most thick-headed one of the class never felt backward in asking about any point that he would not fairly understand; but you may be sure he understood the point thoroughly when the "Old Man" was through with it.

The class was limited to fifteen because the "Old Man" considered that he would not do justice to his students if it were larger, so we all considered ourselves very fortunate to be chosen out of so many applicants, all of whom had to be well recommended.

"Now, gentlemen," continued the 'Old Man', "the most vital point controlling the economical and efficient working of the steam engine is the setting of the valves, and one in which, I'm sorry to say, a great amount of ignorance is displayed by reason of the fact that the subject gets too little thought and study from the average engineer of to-day. We all seem to think that when the engines have been running such a length of time there is no room for improvement, and so long as we keep the brasses tight and the boilers in condition so that they will burn coal and boil water, that it doesn't matter how much coal is burnt or where the product of the coal goes, whether up

the smoke stack in the shape of smoke and gas, or into the condenser in the shape of steam, and such a trifle as economy in consumption is up to the superintendent engineer. Now, the real cause of this style of getting along is not carelessness or indifference, but really gross ignorance; and as I said before, one of the points where this ignorance is most forcibly displayed is in the knowledge, or rather the lack of knowledge, of the relation between the valves and steam consumption.

"Now, take the setting of valves, and the information we get on the subject from text-books. I will take any six different books and I will find six different methods for doing the same thing, and all the books take for granted that the only time an engineer has anything to do with setting of valves is when the engine is being erected, and then most of the methods given are really for marking the key-ways for the eccentrics on the shaft. Again, in most instances, the illustration given is of the slide valve where the casing is off, and you can plainly see the two points of lead and cut-off and those *two points only;* and if the illustration be of the piston valve they invariably make the wrong and misleading statement that the piston valve always takes the steam in the middle or between the steam ports, and consequently the eccentrics must be set exactly opposite to what they would be for a common slide valve. Now this statement is absolutely wrong, and therefore very misleading to the student who should happen to be looking for information on the subject, as piston valves are designed to take steam either in the middle or over the ends, according to the general arrangement and idea of the designer; and, of course, the eccentrics are set to suit, either leading or following the crank. I, myself, have been in a ship of 8,000 horse power where the eccentrics all followed the crank, but she had a slide valve on the L. P. which was worked of a

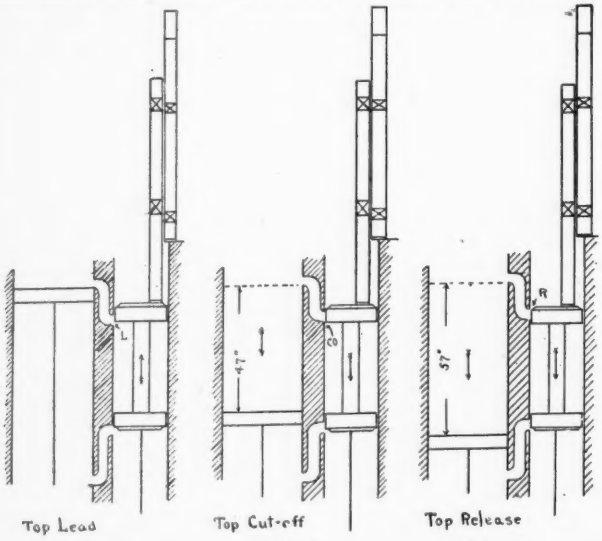


Fig. 1 Fig. 2. Fig. 3

rocking shaft, which, of course, accounted for the eccentrics of the L. P. Engine.

"I have read an article on the setting of piston valves written by some one whose knowledge was evidently derived from some sectional model engine, as it was absolutely impossible to use his method with the piston valve in the casing, which certainly is where we want it when we are taking the setting of the valve. I think I can safely say that I have never read an article on the setting of valves which would give an engineer all the points, namely: lead, cut-off, release, compression and lap on both ends of the valve in one revolution of the engine, so this evening I will endeavor to describe such a method to you in the hope that it will be of use to you in the future.

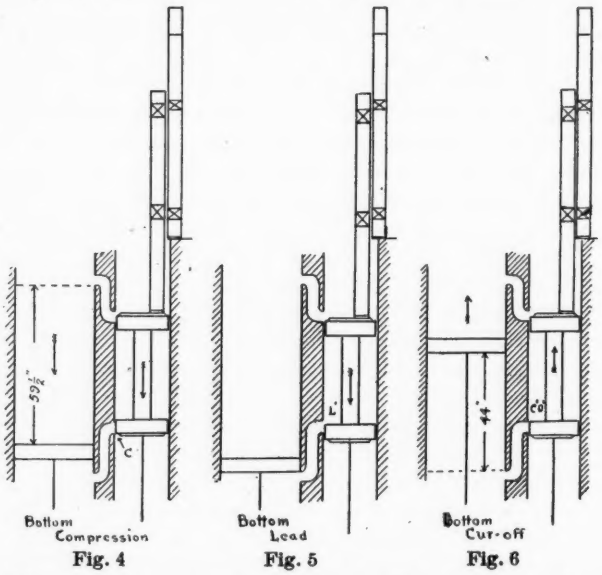


Fig. 4 Fig. 5 Fig. 6

"Now, the dimensions of setting we will use are taken from the horse power piston-valve of a ship which, today, holds three unbeaten records which were made while I was in charge of her machinery. Diameter of horse power cylinder = 38", with a 66" stroke, and diameter of horse power valve = 20" with 10" stroke. Now the first things we have to get are two pieces of white or yellow pine about 7' x 4" x 5/8" thick, and the next, two pieces of bar iron, say 8" x 4" x 3/8", which we will bend at right angles and fasten to ends of wooden pieces. We will now turn the horse power crank on the top centre, when we will put a mark on the guide and on the guide shoe, and then measure the distance from the top of the piston-valve ring to the top of the valve casing or the flange, which we will say is 24"; we will now draw the valve from the casing, and taking one of the pieces of wood proceed to mark off on it the distance between the edges of the top and bottom rings of the valve, using a square and a fine, sharp knife for accuracy, taking care to mark the lower edge of the bottom ring or the exhaust edge higher up than 24"; in this case we will mark it at 28". Next, we will take the other rod and, by going down the casing, proceed to mark off the ports by applying a square from the side of the rod to the edge of the port, by which means we get exact measurements, which, I need hardly remind you, is essential, and before moving the rod apply the square to the top of the casing or flange and draw another line. We will now drop the valve back in the casing, and taking the piece of wood with the marks of the valve casing or ports, we will attach it to the top of the casing by means of one of the pieces of bar iron which we have already made. Now, the distance from the top of the casing to the top of the valve is 24", so we will next secure the rod to the top of the valve at that distance (by means of the other piece of bar iron), as in Fig. 1, which shows us at once that the lead of the valve with the engine on the top centre is 5/8" (marked L in Fig. 1). Now, we will turn the engine in the same direction as she turns

when going ahead, and the next point where we get any two lines together or in line we stop the engine (always being careful to have the lines exact, as very little difference with the lines makes a considerable difference in the various points, owing to the fact that the piston in this instance travels 66″ to the valve's 10″). We will now measure down from the mark which we put on the guide to the mark on the guide-shoe, which we find is 47″, and is therefore the point of cut-off (marked C O in Fig. 2). Now, turn the engine again until we get the next point where any two lines on the rods meet, which you will see is on the exhaust side of the valve, when we will stop the engine and again measure from the mark on the guide to the mark on the shoe, which is 57″, and this will be the point of release (marked R in Fig. 3). Now, gentlemen, I wish to draw your attention particularly to this point and notice that both top and bottom ports are open to exhaust, as I shall have something to say on this subject at some future date. We will now turn the engine and the next point where two lines meet is also on the exhaust side of the valve, but at the bottom port where, if we stop the engine and again measure from the mark on the guide to the mark on the shoe, we will find is 59½″ or 6½″ from the end of the stroke, and therefore the piston has 6½″ to travel when the valve closes to exhaust and compression or cushioning begins (marked C in Fig. 4). Now, the next point we want will have to be taken when we turn the engine on the bottom centre or until we get the crank exactly on the bottom centre, where we will put another mark on the guide in line with the mark on the shoe, and then we

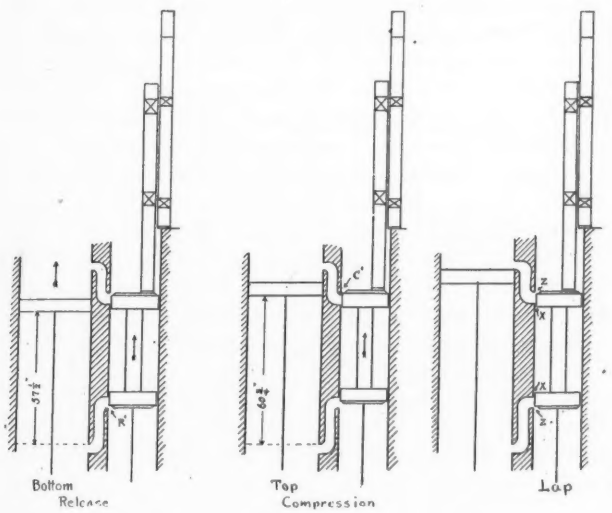


Fig. 7 Fig. 8 Fig. 9

find by the lathes that the bottom lead is 1″ (marked L' in Fig. 5).

"Now, gentlemen, you see that we have completed just one-half of the stroke, and by continuing the turning and stopping at the various points where any two lines on the lathes meet (as we did on the down stroke) and measuring up from the mark we put on the guide when the crank was on the bottom centre to the mark on the shoe, we will get the respective points on the up stroke, which we will find to be cut-off 44″ (marked C O' in Fig. 6), with the release at 57½″ (marked R' in Fig. 7), and the point of compression will be 60¾″, or the piston is 5¾ from the top centre when the exhaust closes (marked C' in Fig. 8).

"If we continue the turning of the engine until we again reach the top centre, stop there and then throw the links over into mid-gear, we can measure the lap of the valve, which we find to be 2¼″ on the top and $2^{5}/_{16}$″ on the bottom (marked X in Fig. 9), or $4^{9}/_{16}$″ total steam lap; but you will again notice that both top and bottom exhaust ports are not closed, and if we measure the respective openings we find that the top port is open ⅜″, and the bottom port is open ¼″ (marked Z in Fig. 9), and therefore we have what is known as negative or minus lap on the exhaust edges of the valve, or a total of ⅝″ negative lap.

"Now, gentlemen, I think I have demonstrated the most simple and, at the same time, most accurate way of getting all the points in the setting of the piston-valve in one revolution of the engine, from which we get the following points in their respective order:

	TOP.	BOTTOM.
Lead	⅝″	1″
Cut-off	47″	44″
Release	57″	57½″
Compression	5¼″	6½″
Steam Lap	2¼″	$2^{5}/_{16}$″
Exhaust Lap	⅜″	¼″

and by next class night I hope you will have studied this out for yourselves, and any point which is not thoroughly understood by you or any question which you may have to ask, I will be only too pleased to explain or answer, as all points must be understood before we can go into the cause and effect of the various points in the working of the engine; and as those points are shown on the indicator card, they must be clearly impressed before we can ever expect to read correctly what the indicator is used for, and what the indicator card shows, as in many cases seeming defects in an indicator card are attributed to water, reducing motion or stretching of the card, which are actually due to the setting of the valve. One such instance I will give you at some future date which occurred with this same horse power valve of which we have taken the setting this evening."

Sausalito, Cal. W. D. R.

Favors Massachusetts License Laws but Despises Special Licenses.

EDITOR THE PRACTICAL ENGINEER:

In reply to J. R. R. and other readers who have attacked the Massachusetts license laws, I would like to speak in favor of these laws, as I have been examined and have passed three different grades and now hold a high-grade license, and on each occasion I consider that I received a fair and just but rigid examination.

These examinations were none too rigid, however, for the power which the respective licenses give to the holder, and I have only a grammar-school education. Why should the dignity of the engineering profession, which so many of us are trying to uphold, by allowing ignorant and uneducated men to obtain high-grade licenses. Circumstances may have prevented a man from obtaining a good school education, but with the number of correspondence schools, books and technical papers that are available, there is no excuse for remain-

ing in a state of ignorance.

If a man is so dense as to be incapable of learning, I don't consider that it is any more proper for him to take charge of the large and complicated plants of today than it would be for such a man to dispense medicine in a drug-store or to treat the sick. Unless an engineer has some knowledge of mathematics, what conception can he have of the enormous power stored up in a boiler? Or how could he intelligently install or advise his employer in regard to some new auxiliary for his plant?

We all are, or should be, trying to raise the standard of the engineering profession. Does the engineer who cannot calculate the heating surface of his boiler or the horse power of his engine tend to raise this standard? The State-house examiners are all practical engineers and fair-minded men, and in my opinion if a man deserves a license he will get it.

The special license, however, is a bane to the engineering profession. It puts a man practically at his employers' mercy. I never saw a special license man yet who was, in my opinion, fit to have charge of a small cook stove. I hope that the special license will be abolished, but that the rigidity of license examinations will be maintained.

Boston, Mass. C. T. P.

Lifting Water.

EDITOR THE PRACTICAL ENGINEER:

Our good friend, Mr. W. H. Wakeman, in commenting on my 40-foot water lift, has evidently overlooked the fact that my article was written in response to a question by R. J., on page 22 of the May issue, as follows: "How can water be delivered to a boiler by a small Deane duplex boiler feed pump placed beside the boiler from a well 40 feet below the surface?" Mr. Wakeman is correct in his statement that I utilize the same principle in my 40-foot lift that he does in his 60-foot lift; but his method would not answer the above question, as he has a pump placed nearer than 40 feet to the *surface* of the water.

About the only difference between our methods is that I use one pump twice, while he uses two pumps once, in lifting water 40 feet; but I agree with him that his method is the best way. By referring to my illustration in the November issue Mr. Wakeman can readily see that I do not make use of any 15 feet of water standing in the suction pipe, as he suggests I may, but the actual vertical distance between the surface of the water in the well and the pump is 40 feet.

The only real difference between Mr. Wakeman's method and mine is that he is showing a practical way of doing it—as his suggestion with reference to a deep well pump would indicate—while I am simply answering a fool question.

Cambridge, O. SCOTT.

The Point is: "Get the Information!"

EDITOR THE PRACTICAL ENGINEER:

In reply to "Golden West," in the January issue, I will say that I do not agre with what he says about Mr. Scott and ads. and catalogues. I think (judging from what he says about the apprenticeship he has served) that he does wrong in expressing himself as he does about Mr. Scott's article, because as a rule a man that has served six years' apprenticeship learns enough in that time to know better.

If Mr. Scott wants to learn, it matters not how he gets the information, from waste baskets, catalogues or from "Golden West." The idea is to get the information and put it where you can use it in time of need. Judging Mr. West from the tone of his letter, he is way above catalogue knowledge.

At the last meeting of the American Society of Refrigerating Engineers, one of the members (and he is some authority, too) made a comparison with some data he had obtained, in which he used a catalogue of the De La Vergne Co. in reference to the horse power required to produce one ton of refrigeration; and credit was given to the source of the information.

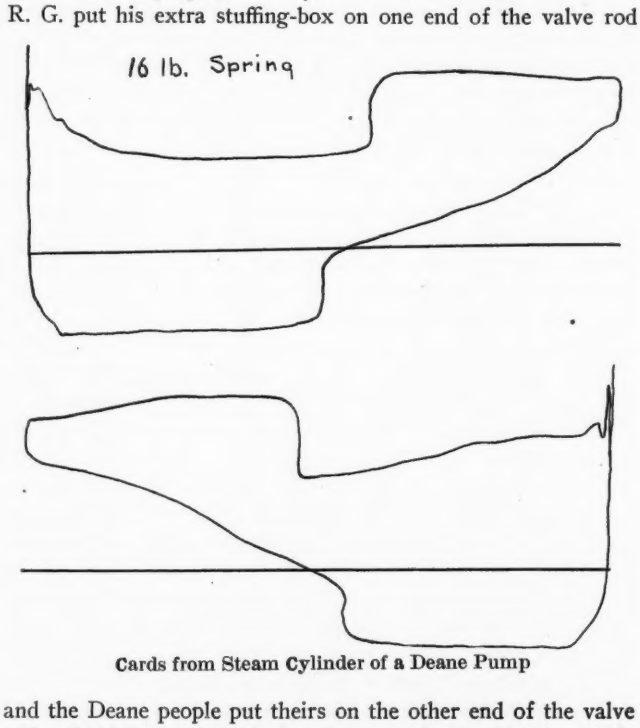
Now, if I wanted to find out how much horse power it required to produce one ton of ice under certain conditions, I would get that catalogue quick and get the benefit of some one's hard labor. I merely mention the above to show that valuable information can be obtained from a catalogue.

Charlotte, N. C. W. D.

Pump Trouble. Stuffing-Boxes Should be Made Deeper.

EDITOR THE PRACTICAL ENGINEER:

In the January issue of THE PRACTICAL ENGINEER I was much interested in the letters from engineers on Mr. Arnold's pump troubles, and I was more than interested in the nice letter from A. R. G. and his explanation and remedy of curing a condensing pump of short-stroking and stopping. His remedy to my mind is exactly the same as that applied by the Deane people, the only difference I can see is that A. R. G. put his extra stuffing-box on one end of the valve rod



Cards from Steam Cylinder of a Deane Pump

and the Deane people put theirs on the other end of the valve rod. I think A. R. G.'s improvement is the better, as his method does not allow steam to leak out if the stuffing-box is not tight, but all the mentioned improvements end up with exactly the same cure, namely, put a little more friction on the valve rod.

Most condensing pumps do not have to discharge water against any head, and the steam pressure is not very great on that account, as the accompanying cards will show. They were taken from a Deane independent condensing pump handling 1,000 horse power, the size of the pump being 16 x 22 x

24 running at 48 strokes per minute in winter. In summer time we have to increase the speed of the pump, as we have to handle more water on account of the increased temperature.

Warren pumps and Knowles pumps, that were not running two months after being installed, had the same trouble of short-stroking and stopping as the Deane pump. Men came from the shop to see what the trouble was, and after making some slight alterations on the tappet arms, they left orders, before going away, that we must be sure to keep those stuffing-boxes on the valve rods full of packing and just set up tight enough to stop the rod from moving except when struck by the tappet arm.

If the makers of pumps and engines would only make all stuffing-boxes deeper, there would be less wear on valve rods and valve stems, and there would be no need of having stuffing-boxes screwed up so tight and packings would last longer, as well as rods and stems.

G. S. N.'s cure of putting a coiled spring between the tappet and the front valve rod rest, looks to me as if it would have just the opposite effect from what he claims.

Fall River, Mass. M. H. H.

Gas Engine Troubles.

EDITOR THE PRACTICAL ENGINEER:

The time has come when we cannot tell when it will be necessary to know a few points about gas engines as with them there comes more or less trouble. I say "it will be necessary to know," because the more we know about the gas engine, the less trouble we will have with them. The man that says anybody can learn all about his engine in a few hours knows nothing about his engine himself. It takes years to learn all about the gas engine. I have been doing trouble work for four years and I learn something new occasionally. I read everything pertaining to gas engines that comes to hand and learn many things. When I began gas engine work I had no one to show me, no one to tell me nor anything to read on the subject.

After the first week I thought I knew it all, and thought I could give pointers to any one in trouble, and I thought there was no trouble I could not find in a moment and overcome; but just about that time my engine began to fail. I tried everything I had done before with no results; there was something else I did not understand. This made hard work for me, as I was alone with a 25 horse power engine which had to be started by main strength. I soon began to think that the man who said: "Anybody without any knowledge of engineering was telling something he knew was not so," knew nothing himself.

I very soon began studying my engine when everything was running smoothly from induction coil to exhaust; the oil piping, the mixing valve, the lubrication of cylinder, the circulating water, the battery, spark-coil, wiring connections, electrodes, contact points, position of igniter, point of ignition. I studied hard and it made my work lighter. I soon found that it was necessary to have fuel within a certain range of the proper mixture and a good spark to ignite it. I remembered trying to start after the engine had suddenly stopped on me. I pulled and sweat and said a few things for about one-half hour, but with no result. I looked the engine over but everything seemed O. K. It would not move only when I pulled it over by main force. I finally stepped to the back door and there before me lay three large drums of distillate. I knew at once what to do and that was to put some of the distillate in my supply tank. Another time I forgot to throw in the switch, but that was soon discovered, and so my troubles would come and go.

The main things about a gas engine are the fuel and spark to ignite it. Most trouble is with the sparking outfit. It is the best plan always to look there first; remove the spark plug, *being sure that the switch is open*—and then step back from engine a few feet and try for a spark. If much carbon has collected on face of plug remove it, as this will short-circuit your battery. See that the movable electrodes work free; go over all connections of wiring, especially on coil, and tighten them; use good batteries. I prefer the Edison type. In setting up this battery be sure that the zinc plates do not come into contact with the copper plate, as this will short-circuit the cell and soon destroy it. If a dynamo is used, set it up where there is no water to splash on it. Do not use your battery box for a tool-box; set it up high out of the way and allow only the battery and coil in it.

If oil is used, it should be strained before going to the supply tank, and if a strainer is in the supply line, it should be cleaned often.

Another trouble is water collecting on the contact points; this short-circuits the battery and no spark is the result. If your engine fails to start readily, work sparker rapidly by hand about a dozen times; this will dry the points.

If your engine has bronze bearings and they should get hot, do not turn cold water on them, as this will ruin your bearing; use oil and let it cool slowly. It will pay to shut down long enough to let it cool.

Los Angeles, Cal. J. M.

Sarcastic Information not Wanted.

EDITOR THE PRACTICAL ENGINEER:

I cannot refrain from expressing my opinion regarding the article written by "Golden West" in the January issue. No up-to-date engineer would say that so far as he expresses the views of Captain Crawford he is wrong, but the rest of his article is uncalled for. He starts this by saying that he wishes to perform an act of "charity" by letting two correspondents "see themselves as others see them," and the result is he has shown himself to be very inconsiderate and sarcastic. He attacks Mr. J. C. Scott's article without consideration and he speaks as though Mr. Scott got his entire knowledge of engineering from the waste basket. There is unlimited information in ads. and catalogues, and a man who is studious can get more information regarding different makes and operation of machinery than he can from hand-books. Now, I am not advocating ads. and catalogues in preference to hand-books, but a number of catalogues supplementing hand-books is what is necessary.

In reference to Mr. Scott's technical library, he suggests a number of authors and immediately tries to belittle Mr. Scott's knowledge by saying that in these books he would find the desired information which worried Mr. Scott so much. This last sentence is uncalled for, as Mr. Scott's article is very good. There are a few remarks which may be misleading, but many of us are not finished grammarians.

In the case of M. L. S., at whom he also sneers, M. L. S. simply stated that as he was doing that kind of work he would

be pleased to know of a rule and trusted to the editor or some brother-engineer to give him a rule which he could use. The information was given by the editor correctly and completely. "Golden West" gives him a rule which is stated too sarcastically and in the end is incomplete. Where he gives his rule for finding the length of the chord, all that he gives is: "Square the two given sides, subtract the lesser from the greater and extract the square root." He has given this rule as though the hypothenuse and one side of a triangle were given. This is, however, not the case, but they must be found. In the case as M. L. S. has given it, the diameter of the tank is 6 feet and the tank shows a height of oil of 5½ feet; then the height of the segment is 6 inches or 0.5 feet. Now, the first thing to be done according to "Golden West's" rule, is to find one-half the length of chord. To do this we must first find the sides of a triangle below the chord, which would be 3 feet for the hypothenuse, and 3 feet minus the height of segiment, or 2.5 feet, would be length of the other side. Then $\sqrt{3^2 - 2.5^2} = 1.65$ feet. This is as far as his rule goes. He should have stated that this result must be multiplied by 2, which equals 3.3 feet, the length of the chord; otherwise his rule for finding the area is all right.

Criticisms and corrections can be given without humiliation and good information is "charity," but "Golden West's" article is "mud-slinging."

Los Angeles, Cal. J. M.

Calculations for Finding Size of Cylinders for 2,000 Horse Power Engine.

EDITOR THE PRACTICAL ENGINEER:

In the December number of THE PRACTICAL ENGINEER J. R. R. challenges me and others to answer the questions which were given by him in the May issue, and he speaks of logarithms as something that a practical man does not need to use. Almost every engineer's hand-book has a table of logarithms and any one using them need not know how they are derived any more than 3.1416 or any other constant. M. H. H., in the July number, has given his solution and F. W. C. works out his answer in the November issue, but I cannot see how they get as many expansions as they do under the given conditions.

I submit my conclusions worked out and I assure J. R. R. that I would like him or any other reader to show me any mistake that I have made in figuring. Absolute initial pressure = 160 pounds; absolute back pressure = 2 pounds; cylinder ratio = 4 to 1; cut-off in high pressure cylinder = ¼; multiplying number of expansions in high pressure cylinder by cylinder ratio (4) gives total number of expansions = 16; dividing 160 by 16 gives a terminal pressure of 10 pounds; the terminal pressure in high-pressure cylinder will be 160 ÷ 4 = 40, but as that would be too high, we will use 25 pounds; receiver pressure of 25 pounds and terminal pressure of 10 pounds will give a ratio of 2.5 in low-pressure cylinder.

To obtain the mean effective pressure of high-pressure cylinder, use the formula

$$\text{M. E. P.} = \text{Init. Press.} \times \frac{1 + \text{hyp. log R}}{\text{Ratio of Expansion}} - \text{Back Press.}$$

$$= 100 \times \frac{1 + 1.386}{4} - 25 = 70.44$$

The mean effective pressure in the low-pressure cylinder will be

$$\text{M. E. P.} = 25 \times \frac{1 + .91629}{2.5} - 2 = 17.16$$

In an engine with a cylinder ratio of 4 to 1, the mean effective pressure in high-pressure cylinder should be four times that in the low, so the load is therefore pretty well divided between the cylinders.

It now remains to find the size of the cylinders. Assuming a speed of 80 revolutions and stroke of 5 feet, and considering all the work done in low-pressure cylinder, we have

$$160 \times \frac{1 + 2.775}{16} - 2 = 35.7 \text{ pounds}$$

as the mean effective pressure, but since only about 65 per cent. is utilized, the actual mean effective pressure becomes 35.7 × .65 = 23.2 pounds. To obtain the area of the cylinder use the formula

$$A = \frac{\text{H. P.} \times 33000}{P \times L \times N}$$

$$\text{from which } A = \frac{2000 \times 33000}{23.2 \times 5 \times 160} = 3556 \text{ sq. in.}$$

which is equivalent to a circle whose diameter is about 37¼ inches. Since this takes into account the 65 per cent. efficiency, I would make the diameter of the high-pressure cylinder 33½ inches and the diameter of the low 67 inches.

A good rule for finding the receiver gauge pressure is as follows:

$$\frac{\text{Initial gauge press.}}{1 + \text{Cyl. Ratio}} - \text{No. of lbs. condenser reduces back press.}$$

In this case

$$\frac{145}{1 + 4} - 13 = 16,$$

giving an absolute pressure of 31 pounds. I have used a lower receiver pressure in the above problem to get an even distribution of the load; 31 pounds would give the low-pressure cylinder 15 per cent. more load than the high.

It is a question in which there is a good chance for argument as to whether it is necessary to equally divide the load between the cylinders. I would like to hear the opinions of others about this point.

N. Abington, Mass. R. D.

The Prime-Mover.

While the past year has witnessed no startling changes or innovations in central power station practice, there have not been lacking indications of progress along various different lines. As regards fuel for steam boilers, the situation has remained unchanged for the past several years. Coal remains the stand-by with natural or liquid oil fuel as a successful competitor where local or special conditions may justify its

use. The use of liquid fuel, in fact, has been for some years a commercial rather than an engineering problem. The conditions for its successful and economic use have been carefully studied by engineers and all factors of the problem are now well in hand. Considering, however, the fact that in most parts of the world the present prices for oil fuel are near or above the margin for economic competition with coal, that long-time contracts cannot be made for such fuel at prices representing economic substitution for coal, and in view, furthermore, of the limitation of oil fuel in points of available distribution in comparison with coal, it is not surprising in spite of its many points of advantage, that oil fuel has, during the past years, made but slight progress with coal as a fuel for station central service. On the other hand, in special localities, as on the Pacific Coast, where oil may be obtained at prices equivalent for steam producing value to coal at $2.50 to $4 per ton, while actual coal rules from $6 to $7 and upwards, it is not surprising that oil should be considered as a normal fuel, and that all problems of power plant design, installation and operations should take the use of oil fuel as a point of departure. These general conditions will continue so long as our steam fuel occupies its present relation to power plant service, and the use of coal or oil will be determined primarily by the economic conditions of the case.

In the matter of steam generators little need be said, as the practice of the year has continued to confirm the use of the large, straight tube type of water-tube or sectional boiler. Regarding steam prime-movers, the field of power plant service at large still remains divided between the reciprocating engine and the steam turbine. The latter has, however, made decided gains in the field of electrical central station service, while the former still holds by far the preponderant place in the remainder of the field of steam power plant practice. In the field of large electrical central station practice in particular, the use of the turbine may be said to have acquired definite status as the normal or standard form of prime-mover. As between the two forms of prime-mover no new arguments have been adduced and no new demonstrations forthcoming. Both still remain in the same class as regards economy, and the advantage of uniformity or angular velocity is met by builders of reciprocating engines with guarantees of performance adequate for all ordinary demands. The various advantages and disadvantages of size, high angular velocity, first cost, maintenance, etc., and which are well known, remain as in the past, and many power plant engineers now consider its advantage for electrical central stations is not by reason of any one feature alone, but due to the general balance, and taking into account all factors entering into the final cost of the output. These conditions seem likely to continue so long as the general factors in power plant service have their present values, and in particular so long as steam continues to serve as the carrier of heat in its transportation into mechanical work. Some progress has also been made in the adaptation of the so-called low-pressure turbine for use with non-condensing reciprocating engines. Such forms of turbine are designed to run on the exhaust of the reciprocating engine and thus without change in the original prime-movers the lower temperature of the steam cycle is extended down to the lower temperature of the turbine, thus improving in marked degree the efficiency of the cycle as a whole. It may be pointed out in passing that due to the mechanical difference in two such types of prime-mover connected together on the same steam cycle, they cannot be both mechanically connected to the same load. At best such hybrids must be considered as justified only by special conditions, and presumably they represent only a passing phase in the gradual adaptation of the turbine to the demands of power plant service. So far as the use of superheated steam is concerned, Continental Europe is still in the lead, especially with reference to its use in reciprocating engines. The advantages of the use of superheated steam with the steam turbine are, of course, well understood, and the use of such steam is frankly accepted as the normal condition for turbine operation. With the reciprocating engine, although the possible gain is quite as much, the mechanical difficulties standing in the way of its realization are more serious, and little progress seems to have been made during the year in the improvement of our practice in this respect.

The various types of gas engine or internal combustion engine, to use the broader phrase, have steadily extended their usefulness during the year and now occupy definitely a not unimportant part of the field of power plant service. The important economic question with the engines of this type is the fuel. Thus, while gasoline is available for the power plant, an automobile or small pleasure boat, or even of a small industrial plant where the power item is small, it could not, of course, be considered for a moment where power is the main output. At the present time blast furnace gas, representing a residue, and producer gas of one type or another and derived from coal, represent the two gaseous fuels available for the development of power on anything approaching a commercial scale. The use of the former is limited by local conditions so that producer gas stands as the present typical gaseous fuel for prime-movers of this type. The field of advantageous application for such engines seems certain to widen, and at the present time there are perhaps no questions of higher interes. to the power plant engineer than those connected with the possibility of the development of internal combustion prime-movers in such form as to be satisfactory for large electrical central station service. In such connection the thought naturally turns to the gas turbine, but the practicable prime-mover of this type seems as far away as ever. Present types of reciprocating gas engines in units adequate for operation of large electrical generators are as yet few in this country, but the extension of the satisfactory use of the internal combustion engine to the operation of electrical central stations of moderate size, is already an accomplished fact and its further extension along the same line seems a foregone conclusion.

Under the general head of auxiliary power plant equipment little need be said. The general methods and appliances available remain the same as for the past few years. More and more attention, however, is being given to the combination of such appliances in such manner as to make for the highest plant economy. Questions of heat balance are forcing themselves more and more prominently upon the engineer, and he is coming to realize that he must scrutinize his energy accounts and strike his energy balance with all the care of a bank clerk with his cash account, and furthermore that he must exert his most strenuous efforts to bring about the reduction of those streams of energy outflow in forms which are non-available and thus increase those in forms which represent a direct useful product—mechanical work, electrical energy, heat or whatever other form it may chance to take.—*Electrical World.*

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

What Causes This Engineer's Trouble?

EDITOR THE PRACTICAL ENGINEER:

As I have been an interested reader of your valuable paper for some time and have got some good pointers from other fellows' troubles, I would like to see if any of the boys will give me some pointers on my troubles. I have charge of a plant in which there are two Corliss engines of the Bates type and I am bothered with the valve stems of the steam valves. These are made with a tee on the inside of the cylinder; the tee fits into the valve and there is a packing ring on the stem between this tee and the bonnet. My trouble is with this packing ring which has a tendency to grind and wear away. I have put in new rings and feed oil in a stream, but to no avail. When I put the rings together I dope them with cylinder oil and graphite, and the rings are fitted with oil grooves. Any suggestion will be appreciated.

Streator, Ill. C. E. A.

What Causes the Engine to Slow Down?

EDITOR THE PRACTICAL ENGINEER:

I am running a Corliss engine of 180 horse power under a pressure of 90 pounds at a speed of 80 revolutions per minute. Under a steady load it will sometimes slow down for about three strokes and then start up again to normal speed. It will do this two or three times a day. I have done everything that I can think of, but it makes no difference. I would like to hear from any one as to the remedy.

Newburgh, N. Y. C. A. B.

By-Pass and Receivers and Reheaters of Compound Engines.

EDITOR THE PRACTICAL ENGINEER:

Please answer the following questions:

1. Explain the use of a by-pass between the high-pressure and the low-pressure cylinders of a compound duplex pump.

2. What is the difference between a receiver and a reheater?

Loraine, O. J. E. W.

1. A by-pass between the high-pressure and the low-pressure cylinders of a compound pump is used only in cases of emergency or when starting. When the pump is first started and the throttle valve is open, the steam must first enter the high-pressure cylinder, and after being exhausted, goes into the low-pressure cylinder. Now, at the moment of starting, there is no steam in the high-pressure cylinder, and since there is the regular pressure on the water end of the pump, the high-pressure cylinder would be incapable of doing this work alone, so that it is usual to turn on the high-pressure steam in the low-pressure cylinder for several strokes of the pump, or until such a time as the exhaust steam from the high-pressure cylinder is capable of doing its proper work in the low-pressure cylinder.

2. The difference between a reheater and a receiver for a compound engine is, that a reheater contains steam coils which are supplied from the high-pressure steam of the boiler, whereas a receiver is nothing more or less than what its name implies; that is, an arrangement for receiving the steam while passing between the high-pressure and low-pressure cylinders of the engine. This is used to avoid pulsation of the steam and to give some storage of steam supply. The reheater is practically the same, except that the live steam coils evaporate any moisture which might be in the high-pressure cylinder, thus allowing the low-pressure cylinder to work under more advantageous conditions.

Method for Bending Pipe.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly tell me how I can bend wrought-iron pipe? I have several pieces that I would like to bend to different curves.

Brooklyn, N. Y. E. M. S.

A method that is often used is as follows: Fill the pipe to be bent with perfectly dry sand and plug or cap the ends so that the filling will be retained under quite severe handling. Care should be taken to have the pipe well filled with the sand and that there is nothing inflammable or damp in it, as the necessary heating of large pipes is very likely to cause a serious explosion. The heating of the pipe may be done in an ordinary forge, and should be restricted to the part of the pipe that is required for the bend; also overheating should be avoided, as the loss from scaling has a very appreciable effect on the bursting strength. The best results will be obtained when the heat is not carried above a full red, as the liability to kinking is less, and in any case it is usually necessary to heat two or three times before a sharp bend can be satisfactorily made, so that nothing is gained by heating to a high temperature. A can of water should be provided, which should have a spout so that a small stream can be directed exactly where needed, as its proper use plays an important part in securing bends without kinks, a point which is highly desirable, as a kink is always an eyesore in the appearance of a pipe, besides seriously reducing its capacity at that point.

After the pipe has been heated to the proper temperature, it is clamped in the vise as close to the location of the bend as possible without grasping the red hot part and the bend started, but first the outside of the curve should be cooled with water carefully applied from the can. The inside of the bend being hot and plastic is compressed as the bend is made with very little tendency toward flattening, but if such a tendency develops, it can be corrected by loosening the pipe and using the jaws of the vise to bring the flattened part back to an approximately circular section. The reason for applying the water to the outside of the curve is that by forcing the bend to take place on the inside of the curve, the pipe walls are better supported by the filing, for the reason that the cubic contents are slightly reduced by the compression; whereas if the exterior of the curve be allowed to stretch, the cubic contents are slightly increased, which allows a small amount of slackness in

the filling at that point and a consequent lack of support to the interior of the pipe. The use of water also plays an important part in the proper formation of the curve, as by its use the pipe may be cooled at a point where the required curvature has been obtained and still leave the remainder in a condition to be bent as desired. When bending pipe without formers, it is necessary to have a template, which may be made from a ¼-inch rod bent to the desired curvature, which, being laid on the pipe while bending, gives a guide for the operator. The use of water for cooling the outside of the curve can usually be dispensed with when the radius equals or exceeds fifteen times the diameter of the pipe.

When bending butt-welded iron pipe, care should be taken that the seam comes on the inside or the outside of the curve and not on the sides, as the seam is much more likely to crack open in the latter position. Considerable experience, however, is required before the best results can be obtained in hot pipe bending.

Setting Harris Corliss Valves.

EDITOR THE PRACTICAL ENGINEER:

Seeing your willingness to answer questions, I would like to know how to set the valves on a Harris-Corliss engine.

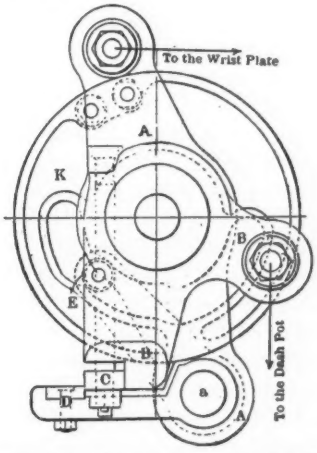
St. Louis, Mo. F. R. D.

The type of releasing gear used on a Harris-Corliss engine is shown in the accompanying sketch. The lever AA carries the shaft *a*, to one end of which is keyed the grab hook D and to the other end, the trip lever, carrying the roller E, which slides in the groove of the knock-off cam K. The drop lever BB carries a movable die C, suspended by a bolt, thus allowing it to rise as the hook D passes backward under it. As the lever A moves in the direction indicated, the valve is opened and remains so until the roller E is thrown downward by the cam slot, disengaging the grab hook D and releasing the valve. The cam is so constructed that should the speed of the engine become very slow or should the governor belt break, the D would fail to engage with C, as in the case of all releasing gears.

The method of setting the valves is given as follows:

Radial lines showing the opening, or working, edges of ports and valves, will be found on the back bonnet side of cylinder at the back end of the valves, as follows: For the steam ports, a mark on the cylinder coinciding with that edge of the port toward the end of the cylinder; a mark on the back end of the valve coinciding with the edge of valve toward end of cylinder. The lap movement of the steam valve is toward that end of the cylinder in which the valve is located. The exhaust valve covers, or works over, the opening from the valve chamber into the exhaust chest, and the opening edge is that side of the opening toward the centre line of the cylinder, and has its coinciding mark upon the cylinder. The mark on back end of exhaust valve shows its opening edge. The wrist plate is located central between the four ports on the front bonnet side of the cylinder, and has marks on the upper side of its hub showing the extremes of its travel and its centre of motion.

To set the valves, place and hold the wrist plate on the centre mark, or at the centre of vibration, and by the adjusting threads for shortening and lengthening the valve connections, set the exhaust valves at the point of opening, and lap the steam valves from ⅛- to ⅜-inch, according to size of engine, the less amount for an 8-inch cylinder, and the larger amount for a 30-inch cylinder, and intermediate sizes in proportion. Now connect the wrist plate and eccentric by the eccentric rod and hook, and, with the eccentric loose upon the shaft, roll it over and note if the wrist plate vibrates to the marks of extreme travel; adjust at the screw and socket in the eccentric rod, to make it vibrate to the marks. Now place the crank upon either dead centre, and observing at this time in which direction it is desired to run the engine shaft, roll the eccentric enough more than a quarter of a revolution in advance of the crank to show an opening of the steam valves nearest the piston of from $^1/_{32}$ to ⅛ of an inch, according to the speed the engine is to run. Now tighten securely the set screw in the eccentric, and turn the engine shaft over in the direction desired to run it, and note if the other steam valve is set relatively the same; if not, adjust by shortening or lengthening its connection. At a state of rest the weight of the regulator, or governor, balls rests upon a pin in the side of the regulator column.



Releasing Gear of Harris Corliss Engine

To adjust the cam rods, have the balls resting upon the top motion pin; then move and hold the wrist plate to one extreme of its throw, and adjust the cam rod for the steam valve, now wide open, so as to bring the steel cam on the cam collar into contact with the circular limb of the cut-off hook; move the wrist plate to the other extreme of throw, and adjust the other cam rod in the same manner. To test the correctness of the cut-off, block up the regulator mechanism to about its medium height, and with the eccentric connected to wrist plate, roll the engine shaft very slowly in the direction it is to run, and when the cut-off hook is detached by the cam, stop and measure upon the guide the distance traveled by the crosshead; then continue the revolution of the shaft, and note when the other steam valve is tripped. If cut-off is equalized, the distance traveled on the guides will be the same; if not, adjust the cut-off rods until the points of cut-off measure alike. The pin in the side of the regulator column upon which the weight of balls rests, is to be removed when the engine is in motion and up to speed, to allow the stop-motion cams to become operative, and stop the engine in case of any breakage of the governor belt, which would allow the engine to run away unless thus guarded against.

Injector Question. Gauge and Atmospheric Pressures.

EDITOR THE PRACTICAL ENGINEER:

1. Will an injector work if connected so that it will discharge into the steam space of a boiler?

2. Why do you figure pressures from the atmosphere? Are all gauges made to indicate pressures per square inch?

3. How do we know that the atmospheric pressure at sea level is 14.7 pounds per square inch?

Cleveland, O. G. L. S.

1. An injector, if properly conected up, will discharge into the steam space just the same as it will discharge into the water space of the boiler, because the momentum of the water when passing through an injector is sufficient to overcome the pressure of the boiler, and since the pressure in the steam space is the same as the pressure in the water space, there is no reason why it should not work.

2. Pressures are figured from the atmosphere because the atmosphere is always acting upon all surfaces, so that gauge pressure is always reckoned from the atmospheric pressure as zero. Gauges are made to indicate pressures in pounds per square inch, because that is the generally assumed unit. Gauges can be made to read in other pressures, such as pounds per square foot, or pounds per one-half square inch. A steam gauge is calibrated originally by putting certain weights upon a piston, whose area is exactly one square inch, and finding out what the gauge will record, so that any pressure which it will subsequently record will be in pounds per square inch.

3. We know that the atmospheric pressure at sea level is about 14.7 pounds per square inch, because we know that if one end of a glass tube be immersed in mercury and the other end contains a vacuum, the mercury will stand in this tube about 30 inches in height, and since this column of mercury must balance the pressure of the atmosphere and knowing the weight of a cubic unit of mercury, we can easily obtain the fact that the pressure of the atmosphere is about 14.7. Any other liquid can be used, such as water, in which case it is found that the column of water 30 feet high will about balance the pressure of the atmosphere.

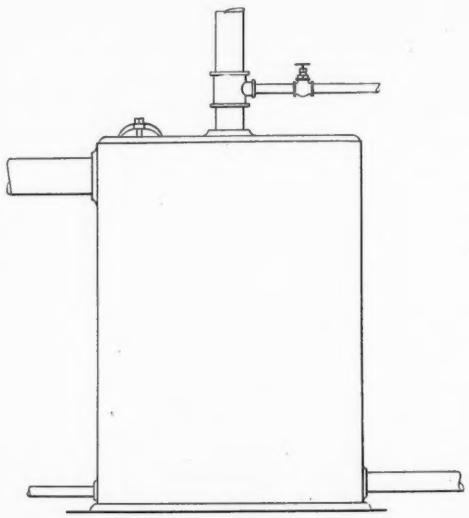
Concerning Blow-Off Tanks.

EDITOR THE PRACTICAL ENGINEER:

While the blow-off tank shown in Fig. 1, page 16, of the December issue, is very good, I have one in use that is quite different which has given satisfaction for more than 12 years. (See illustration.) Water from the boilers enters through the lower right-hand pipe which is 2 inches in diameter. An outlet is provided at the lower left-hand side which is 1½ inches in diameter. As there is not a heavy pressure on the tank, this outlet to the sewer has not proved objectionable, and it drains nearly all water out of the tank after the blow-off valves are closed.

When a boiler is blown down in the morning, it quickly fills the tank so that the outlet is sealed against the escape of steam, which goes out of the three-inch vent pipe coming out of the top. A cold-water pipe is conected into this vent for the purpose of condensing the escaping steam. If water is admitted before the blow-off valve is opened, it creates excessive vibration of the tank and all connecting pipes which would soon cause leaks if continued. A 3-inch outlet at the upper left-hand side allows hot water to escape to the sewer, and after the blow-off valves are closed cold water is admitted to the vent pipe, and the whole tank is thereby cooled off.

The tank that you illustrate has no way of draining off the water, hence it will stand level with the inlet unless it is siphoned out by the outlet which is continued down into the body of the water. If this water does stand on a level with the inlet, and it is allowed to become cold, will it not cause trouble when one of the blow-off valves is opened and very hot water discharges into this cold tank? There is danger here.



A Blow-off Tank

The convex head that you show is a very strong form of construction, but would it not be better to continue the shell down a little below the centre of the head, thus forming a more suitable bottom to set on a foundation?

W. H. WAKEMAN.

Valves on Steam Mains.

All the valves on the steam piping should be so located as not to collect water, when either closed or open. When the pipe rises from the boiler with a long bend, the stop valve should then be at the top of the bend and at some distance from the boiler connection. There is no objection to this arrangement. The valve thus placed will generally be more accessible, and when closed less surface will be exposed for radiation.

Globe valves should not be used on horizontal pipes, as they necessarily form a pocket for water. On small pipes, an offset globe valve may sometimes be used, but in all cases it is generally better to use a gate valve with a screw movement. If the pipe is large, it is well to provide a by-pass in connection with the gate valve.

A gate valve should always be placed with the spindle vertical, but when head room is wanting the valve may be placed horizontally. Gate valves should never be set with the spindle pointing downward, as then the valve will always form a pocket, no matter what the opening may be, and the gate is liable to be damaged by water hammer when partly open.

A stop valve placed directly on the boiler nozzle with a ver-

tical pipe leading from it, is a very bad arrangement, as water is sure to collect. If such an arrangement cannot be avoided, place a drain on the upper side of the valve. It would be better to place an angle stop valve on top of the vertical pipe and have the supply main properly pitched away. As stop valves on tops of boilers are often inconvenient to reach, an elbow can be placed on the boiler nozzle and the pipe led from it with the valve located at some accessible point. This pipe should pitch from the valve in both directions. This arrangement is very good when head room is low.

All valves should be located for easy accessibility, in order to facilitate rapid control. It is well to group them as near together as may be convenient on this account. Usually in large stations, the valves can be so placed as to be reached from a light platform or gallery suspended from the roof trusses.

Some Practical Kinks.

By Wm. Kavanagh.

A very handy device for the testing of no-arc fuses is shown in Fig. 1. A piece of slate is drilled to receive two small bolts, as shown at A and B, two pieces of sheet copper or brass are drilled near their ends to receive the bolts. Those pieces are fastened to the slate which in turn is connected to the bus-bars or other convenient source of current supply; there is a lamp connected in one of the mains, as shown at L, and the pieces of copper are bent at such an angle that the smallest or largest fuse can be tested by placing it across that part of the angle which will suit its length, the small fuses being placed across the angle at its closest part, while the larger fuses are shifted

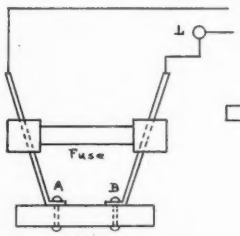


Fig. 1

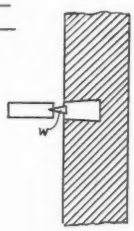


Fig. 2

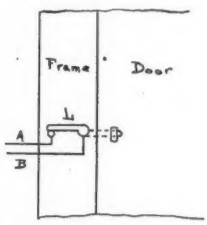


Fig. 2

outwards, as shown in sketch. If the fuse is good the lamp will light, and in this manner a large number of no-arc fuses can be quickly tested.

In fastening motor platforms, or platforms for other purposes, to walls, it sometimes happens that expansion bolts cannot be had, so that the next best thing to do is to use dowels wedged at one end, as shown in Fig. 2. The holes are drilled in the walls to receive the dowels and the holes are made slightly tapering, the smallest diameter being outside. A wooden plug or dowel is fitted to the hole and then sawed to receive a wooden wedge, as at W. The slot to receive the wedge is filled with glue and the wedge is partly pushed in the slot. Now take the plug, wedge end first, and drive it into the hole; the wedge will enter the plug and expand it after the manner of an expansion bolt. After the glue has dried, it will be found that the plug cannot be taken out under ordinary conditions. Any platform bolted to those plugs may be relied upon to remain firm; of course, any portion of the plug protruding beyond the wall surface can be sawed off before attaching the platform.

Modern ice boxes are fitted with one or more incandescent lamps and various plans have been adopted to eliminate all the heat possible from the boxes. The lamps usually have a switch attached outside the box for the purpose of turning on and off the light; usually the person having business in the ice box neglects to turn out the light, so that a considerable amount of heat is radiated from the lamp with a consequent waste of ice. An arrangement which is attached to the bolt that keeps the ice-box door closed is shown in Fig. 3, which makes it impossible to maintain the lamp burning so long as the ice-box door is shut. The wires A and B are connected to one side of the door frame, and when the door is opened and the lever L connects them, the lamp lights. In closing the ice-box door, the lever L is thrown over, thus raising it from A and breaking the circuit, making it impossible to keep a light burning so long as the door is properly shut.

Copper Steam Pipes.

When copper pipes are used for steam, the following rule should be taken as a minimum:

$$\text{Thickness in inches} = \frac{p \times d}{6000} + \frac{1}{16},$$

when brazed and

$$\text{Thickness in inches} = \frac{p \times d}{6000} + \frac{1}{32},$$

when seamless, not exceeding 8 inches in diameter, in which

p = working pressure in pounds per sq. in.
d = inside diameter in inches.

Long bends should be made one gauge thicker than straight parts, and short bends two gauges, as the material on the outside of the bend is thinned by bending.

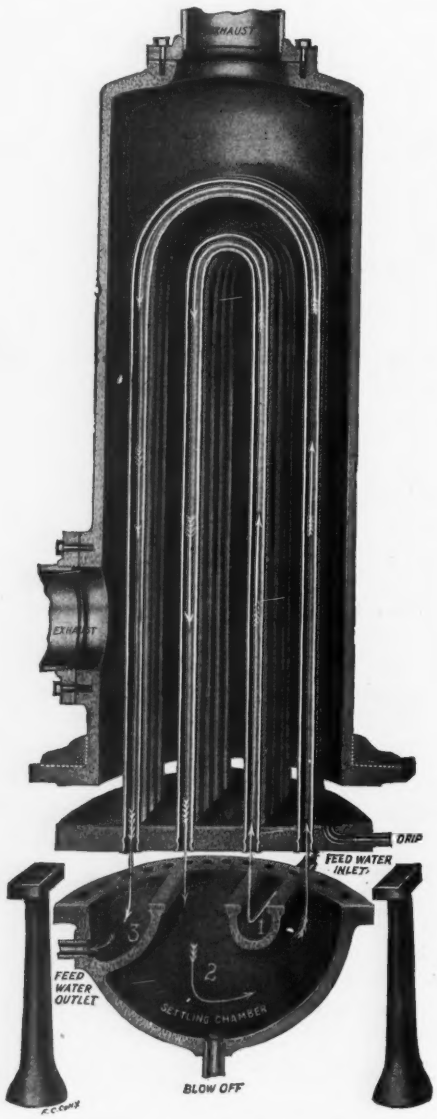
The general design of the steam piping is all-important. Short and direct connections between boiler and engine, with consideration for expansion and drainage, are to be preferred, as being simple and offering least loss from condensation. Design the piping so that there will be no pockets, but if pockets must be formed, make them as few as possible and of ample size with drains. It is an easy matter for steam flowing at 8,000 feet per minute to pick up water and carry it along.

The Patterson-Berryman Feed-Water Heater.

The efficiency of any feed-water heater depends upon the ability of the metal walls to transmit the heat from the steam to the water and the amount of circulation which the water receives in passing through the heater. The Patterson-Berryman heater, shown in the accompanying illustration, answers these requirements and as a result they will be found in many power plants where the advantages of heating the feed water and collecting the impurities before they enter the boiler are recognized.

The heater belongs to the pressure type and consists of an iron shell and settling chamber with V-shaped brass tubes expanded in a heavy cast-iron tube head. The feed water passes in and through the nest of tubes, and then owing to a partition in the settling chamber, the water passes through another nest of tubes and finally out to the boiler. The settling chamber in the bottom of the heater catches the impurities which

can be blown out from time to time when found necessary. The exhaust steam enters the heater at the side, and after passing outside of the tubes, it passes out of the top to the atmosphere or elsewhere as desired. The tubes are made of seamless drawn brass.



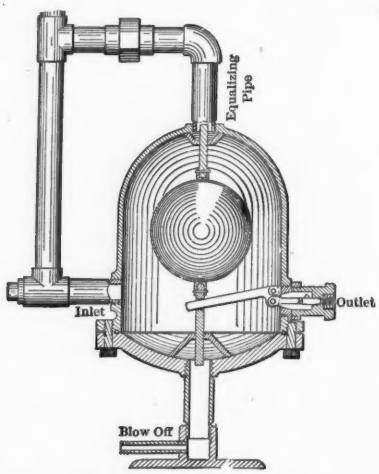
The Patterson-Berryman Feed Water Heater

The Patterson-Berryman feed-water heater is manufactured by Frank L. Patterson, 24 Cortlandt Street, New York City, where other information may be obtained if desired.

The Burrows Steam Trap.

The function of a steam trap is to catch the water of condensation from a steam pipe and to eject it from the piping system in such a manner that none of the steam is lost by the operation. There are various methods for doing this, the simplest of which is the float principle, which regulates the discharge valve. The movement of the float, however, is always of greater amplitude than that required by the valve, so that by means of a proper system of levers, the movement of the float can be concentrated upon the valve and hence exert a positive influence of more or less great magnitude.

The Burrows steam trap, shown in the accompanying illustration, has adopted this principle and the float, instead of lifting the valve directly, lifts a horizontal lever to which the valve is attached and it is thus able to handle a smaller valve with greater positiveness or to open a larger valve against a given pressure. An equalizing pipe prevents the trap from becoming air-bound.



The Burrows Steam Trap

The shell of the trap is made in such a form as to withstand the maximum pressure with the minimum weight of material, and the interior is accessible by removing the bolts of the bottom cover. The trap is equipped with a blow-off connection, so that any scale or sediment that may collect in the trap may be blown out without interfering with the outlet valve.

The Burrows Manufacturing Co., 73 Warren Street, New York City, are the manufacturers.

Book Reviews.

Modern Steam Engineering, by Gardner D. Hiscox. Size, 6½ x 9¼. 487 pages and 405 illustrations. Published by the Norman W. Henley Publishing Co., 132 Nassau Street, New York City. Price, $3.00.

There have been from time to time many books published on the subject of steam engineering intending to include within their covers all the many subjects which come within the scope of this broad field, but of all these books which have come to our attention the above book seems to have fulfilled the wants of the engineer and student better than any that we have seen. It is well written, thoroughly up-to-date and each subject is taken up in a more or less thorough manner without slighting any other one. There are forty-two tables in the book which are valuable for reference.

Beginning with a brief historical introduction of the steam engine, the book takes up the properties of steam; the generation of steam, including furnaces, grate-bars and mechanical stokers; types of boilers; chimneys; feed-water heaters and fuel economizers; incrustation in boilers; condensers; air pumps; cooling towers; flow of steam through orifices, nozzles and pipes; superheated steam and superheaters; indicators and their application; steam engine proportions; various forms of valve gears; Corliss engines of various types and

the method of setting valves; compound engines; triple and quadruple expansion engines; the steam turbine; mechanical refrigeration; types of elevators, air compressors and blowing engines; cost of power; duties of the engineer; operation of dynamos; testing and motors; switchboards and storage batteries; lighting and lamps.

The book is well illustrated and well printed, and the character of the information makes it well worth its comparatively low cost.

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Combustion and Smokeless Furnaces, by Joseph W. Hays. Size, 6½ x 9¼. 101 pages and 15 illustrations. Published by the Hill Publishing Co., 505 Pearl Street, New York City. Price, $1.50.

Each author who writes on the subject of smokeless combustion usually has a theory more or less his own as to what takes place in the fire-box of a boiler, what causes smoke and how it can be prevented. The above book, however, treats this subject in a rational manner. Beginning with the chapter on Heat and Combustion, which discusses the measurement and mechanical equivalent of heat, the chemical reactions which take place in the furnace, the amount of heat produced and the effect of air supply and furnace efficiency are taken up. The "chimney evil" is strikingly portrayed, after which the requirements of smokeless combustion and mechanical stokers and hand-fired furnaces are discussed.

The discussion of the use of Dutch ovens and enveloping tile is the most interesting part of the book, which is written in simple language without any confusing mathematics or chemical formula.

———o———

Modern Milling Machines, by Joseph G. Horner. Size, 6 x 8½. 300 pages, 270 illustrations and numerous tables. Published by the Norman W. Henley Publishing Co., New York City. Price, $4.00.

This book describes and illustrates the milling machine and its work. It describes the early machines of this class and develops the subject up to the modern complicated machines of the present day, giving the various types, forms and special features of machines of different manufacturers. Among the subjects taken up are plain and universal milling machines, attachments and bracings, vertical spindle machines, cutters, milling operations, indexing, spiral, worm, spur and bevel gears, and feeds and speeds.

There is perhaps no machine in the machine shop which is so little understood and about which more questions are asked than the milling machine, and to those persons who wish to obtain a more thorough knowledge of the mechanism and its uses, this book is recommended.

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Boiler Waters, by William W. Christie. Size, 6 x 9. 230 pages and 71 illustrations. Published by D. Van Nostrand Co., 23 Murray Street, New York City. Price, $3.00.

The above book gives in a clear, concise manner the various causes of boiler scale, corrosion, priming and foaming and the different methods of preventing impurities from reaching the boiler. The key-note of the book is struck in the following four sentences which Mr. Christie uses as part of the preface: "A steam boiler is a steam generator, not a kettle for chemical reaction"; "get, if possible, a supply of clean, soft, natural water"; "the only compound to put in the boiler is pure water"; "oxygen, the most useful element, is, when free in boilers, a most destructive, corrosive element."

In the chapter on the properties of water, the impurities are described and the method and result of water analysis are given. In the chapter on boiler scale, various photographs of boiler scale are shown, and the result of scale on evaporative power of a boiler is shown. In the chapter on corrosion, both external and internal corrosion are described. This chapter is most interesting as many curious results of the use of different kinds of water are given. Other interesting chapters are those describing the different types of feed-water heaters and water purifying systems.

This book should prove very useful to the plant owner or engineer, as the less scale there is in a boiler, the more efficient will be the generation of steam.

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Practical Lettering, by Thomas F. Meinhardt. Size, 9 x 14, paper cover, 15 pages, fully illustrated. Published by Norman W. Henley Publishing Co., New York City. Price, 60 cents.

There are very few persons who thoroughly understand the correct methods of forming letters and properly spacing hem. A drawing or engraving may be ever so well executed, but if the lettering is not done properly, the appearance is spoiled. The above book takes up this subject in a systematic manner, so that not only will the letters be correctly formed, but the spacing between them will be accurate, so that the general appearance of the finished title must necessarily be pleasing. Considering that there are 676 combinations possible in lettering, some fixed rule should be had, and this the author has solved. Besides this information hints for pen-work, hints on duplication and analysis of letter construction are included in the book, which should be useful to any one interested in lettering of any kind.

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Atlantic City Council.

The annual banquet of Atlantic City Council, A. O. S. E., was held at the Hotel Raymond, Atlantic City, on Saturday evening, January 12th, covers being laid for 120 members and guests. H. G. McConnaughy, of the Dearborn Drug and Chemical Works, presided as toastmaster, and the occasion, like all the entertainments of this council by the sea, was an enjoyable one. The principal speakers were Wm. G. Le Compte, of Jenkins Bros.; C. P. Williams, Geo. W. Richardson, William Schatz and John Armour. Among the visitors present were Chas. J. Curran, of the O. F. Zurn Co., the popular Philadelphia oil house; John R. Livezey, the well-known expert on pipe covering and cold storage insulation; Frank Mellor, of the Electric Storage Battery Co.; Harry Souder, and others.

The officers of Atlantic City for 1907 are as follows: Chief, B. G. Colescott; assistant chief, W. A. Hardin; secretary, W. S. Price, Haddon Hall; financial secretary, C. F. Noble; treasurer, R. S. Peterson; chaplain, Warren Morris; Sr. M. M., Frank Colescott; Jr. M. M., Fonse Seimes; sentinels, Martin Schlange and J. H. Hickman; trustees, J. H. Frampton and John A. Best.

TRADE NOTES

EDITED BY THE ADVERTISING MANAGER

All trade marks, copyrights, formulas and patents for the manufacture of the well-known Lubron products, have been acquired by the Knowlton Packing Co., 14 L St., So. Boston, Mass. The Lubron specialties include hydraulic packings, ammonia packings, special spiral, tubular gaskets, leather cups and Lubron lubricants. The success of this splendid line of specialties will be still further advanced by the new owners. A catalog discribing the complete line will be mailed to any engineer upon request.

The Pittsburgh Gage & Supply Co., Pittsburgh, Pa., are installing a large number of White Star Continuous Oiling Systems. The simplification of handling oil, the feeding of a regular supply to the bearings, the elimination of wastage over hand oiling, and the mechanical purification of the used oil, thereby cutting the oil bills down and reducing cost of attention to minimum, with the certainty of copious lubrication has led such representatives as the following to specify and install the White Star Systems: Brier Hill Iron & Coal Co., Youngstown, O.; Embree Iron Co., Embreeville, O.; Sargent & Co., New Haven, Conn.; National Car Wheel Co., West Homestead, Pa.; Copper Queen Sons Mfg. Co., Douglas, Ariz.; Brosh Elec. Light & Power Co., Galveston, Tex.; Illinois Steel Co., Joliet, Ill.; Consol. Gas, E. L. & P. Co., Baltimore, Mr. Their catalog on oiling systems is to be had by any one interested.

A fine large calendar, size 15 x 20 inches, with a separate sheet for each week, has just been issued by the D. T. Williams Valve Co., Cincinnati, Ohio, one of which will be sent absolutely free to every reader of THE PRACTICAL ENGINEER, mentioning this paper. Those who wish one must write immediately as the supply is limited.

The Crandall Packing Co., Palmyra, N. Y., have sent us a copy of their latest catalog just off the press. It is printed in colors and the engravings showing their various styles of packing are excellent. We presume that a copy will be mailed to readers upon request.

James Bonar & Co., Inc., of 716 Frick Bldg., Pittsburgh, have on hand at the present time, thirteen (13) complete automatic continuous oiling systems to install. They have just closed with the Carnegie Steel Co., for three systems for the Duquesne Steel Works, one for the Jones & Loughlin Steel Co., and one for the Pittsburgh & Butler Street Railway Co., at Renfrew, Pa. Their catalog on oil filtration is very interesting, and will be sent to any one interested in this line.

The advantages of the Swartwont Cast Iron Exhaust Head, embodying the principle of centrifugal force, is instructively described in a booklet issued by the Ohio Blower Co., 43 Michigan Avenue, Cleveland, Ohio. They are now pushing for new business, and from reports which we are constantly hearing, they are successful. They tell us that engineers would do well to send their name and address, as they have a special proposition to make.

Unique Flexible Combination Cleanser and Blower for boiler tubes, the Unique Separators, Exhaust Heads and Metalilc Packing Rings are described in a neat little booklet published by Unique Engineering Co., 5 and 7 Beekman Street, New York.

The Philadelphia Lubricator and Manufacturing Co. extend a cordial invitation to readers of THE PRATCICAL ENGINEER to visit their new exhibit in the machinery department of the Philadelphia Bourse.

Engineers having house tanks under their charge, especially the kind that overflow occasionally, or threaten to do so at some unexpected time, should write for catalogue to the American Boiler Economy Co., 741 Mutual Life Building, Philadelphia.

Our readers may be interested in knowing that the Knowlton Packing Co., of South Boston, Mass., have purchased the Right and Patents to the Lubron Special Products. They have on hand a complete lot of Lubron stock and are in a position to fill orders promptly. These Lubron Products consist of Hydraulic Packing, Spiral Packing, Ammonia Packing, Moulded Packing, Hot Water Valves, Tubular Manhole Gaskets, Leather Cups, Gas Gauge Reflectors and Lubron Lubricants. The success of these products will, no doubt, be continued under the new company.

The Revere Rubber Co., 77 Bedford Street, Boston, Mass., will send a handsome turtle paper weight to anyone who fills out and mails the coupon in their advertisement on page 61 of this issue.

EVERY LIVE ENGINEER SHOULD HAVE THESE

BOOKS

THE CORLISS ENGINE, by John T. Henthorn, and "The Management of the Corliss Engine," by C. D. Thurber. This is a practical hand-book for Engineers and their Assistants. 52 illustrations, attractively bound in cloth. Price, $1.00.

A, B, C OF THE STEAM ENGINE, by J. P. Lisk, M. E. Just the book to give practical help to Firemen Helpers and Young Engineers. Price, 50 cents.

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DIAGRAM OF THE CORLISS ENGINE. Makes it easy to know more about the Corliss Engine. Longitudinal Section of Engine Cylinder, showing Relative Positions of the Piston, Steam Valves, Exhaust and Wrist Plates when cut-off takes place at ¼-stroke for each 15 degrees of the circle. Size, 13 inches by 19 inches. Price, 25 cents.

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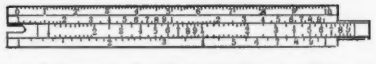
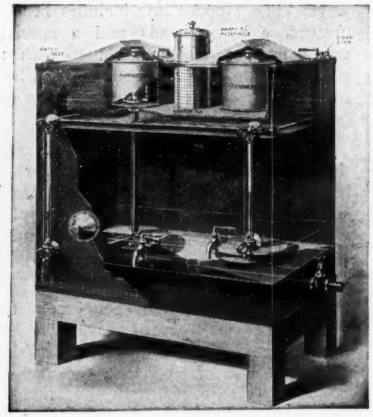


F. F. NICKEL, 27 Winans Street, East Orange, N. J.



Stop That Oil Waste With Unit Oil Filters

You know that by dripping anywhere from 50 to 90 per cent of oil is being wasted every year. If you will gather and cause it to pass through the "Unit," you will have clean oil and this waste may be used over and over again.

One "Unit" works just as efficiently as a number and has a capacity of from 200 to 250 gallons every 24 hours, so as the plant increases, additional "Units" may be added.

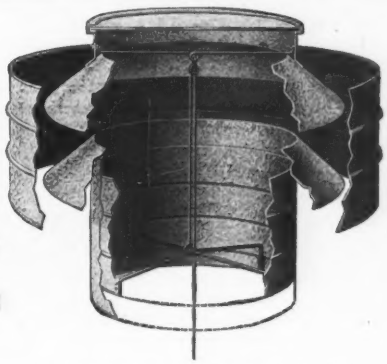
Our new 64-page Catalogue is the most handsome ever issued by any oil filter concern and fully describes the "Cross, American, Warden and Unit" Oil Filters, the "Burt and Standard" Exhaust Heads and the "Burt" Ventilator. A copy awaits your address.

The Burt Mfg. Co.

Largest Manufacturers of Oil Filters in the World

204 Main Street AKRON, OHIO, U.S.A.

The Burt Ventilator



Sectional view glass top, showing sliding sleeve damper (patented)

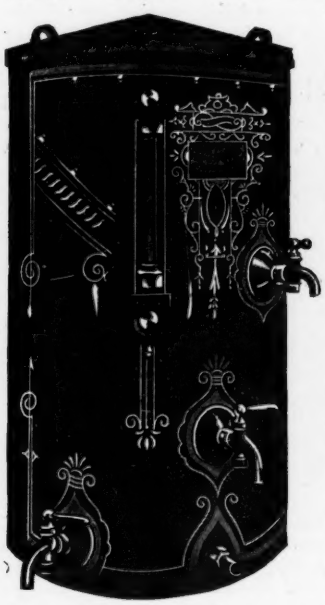
brings daylight and pure air to the engine room. It will remove hot air, smoke, steam, etc. without lowering the temperature too far for comfort. Our sliding sleeve damper has no flat surface to collect dust and refuse, it always remains in one position, unaffected by air currents, and when closed is absolutely stormproof, yet does not affect the passage of light. Used by the largest plants all over the country.

The Burt Mfg. Co.

Largest Manufacturers of Oil Filters in the World

204 Main Street, AKRON, OHIO, U. S. A.

The Cross Oil Filter Means



Money in Your Pocket

because it removes dirt and grit from your lubricating oil by straining it through waste, then washing it in pure, warm water. Requires practically no attention after starting, nor any great expense to maintain it—just a few cents per year for waste. Has nothing to break or get out of order and cannot clog.

The Burt Mfg. Co.

Largest Manufacturers of Oil Filters in the World

204 Main Street AKRON, OHIO, U.S.A.

Your Roof and Sidewalk Kept Clean By Burt Exhaust Head

It will positively remove water and oil from exhaust steam lines.

It contains no baffle plates, diaphragm or scrap metal.

Is built from extra heavy iron, lapped, riveted and soldered.

The Burt Mfg. Co.

Largest Manufacturers of Oil Filters in the World

204 Main Street, AKRON, OHIO, U. S. A.

Jenkins Brothers' new catalogue for 1907 has just reached us, and it's a beauty; 128 pages, 6x9 inches, with over a hundred half-tone cuts and many sectional views, all splendidly printed on fine coated book paper and the cover in colors. It shows the entire line of Jenkins' products from the famous old Jenkins globe valve to the Empire extra heavy gate valves which is the newest, but by no means the least of the Jenkins line. In addition to the regular line of valves numerous specialties are shown, all of which will interest engineers, and there is also a deal of useful information in the tables of sizes, capacities, etc. A copy will be mailed to every reader of THE PRACTICAL ENGINEER who writes at once to Jenkins Bros., 133 North Seventh Street, Philadelphia.

We have received a very handsome calendar for 1907 from the Kutztown Foundry & Machine Co., 116 North Broad Street, Philadelphia. This concern makes a specialty of manufacturing boiler fronts, grate bars, furnace castings, compound separators and general boiler castings of all kinds. They are also equipped to make special castings for the trade or for anyone who is in need of such work.

The H. W. Johns-Manville Company, of New York, have opened a new branch store and warerooms at New Orleans, corner of Baronne and Perdido Streets, where they will carry a full line of their asbestos and magnesia products.

A catalogue of Homestead valves will be sent to anyone upon request. The special claim made for these valves is that the seat is protected from wear as the pressure passes through. The plug is balanced and held in place by the pressure when open, and when closed it is locked in the seat by a patent wedging cam, insuring freedom from wear or friction, while plug is turning. Address Homestead Valve Mfg. Co., P. O. Box 1754, Pittsburg, Pa.

The postal authorities at Washington have decreed that no more coupons shall appear in the advertisements of any paper or magazine after March 1st next, claiming that coupons when so inserted become writing paper and cannot be admitted at second class postage rates, so this is the last opportunity to fill out a coupon and clip it from the pages of THE PRACTICAL ENGINEER. In this issue there is a coupon in the advertisement of Revere Rubber Co., which will be found on another page. It will not appear again, so use it if you are interested. It will be your last chance, and you will get a handsome little turtle paper weight free. These pretty metal turtles are sent simply to advertise Usudurian (Turtle Brand) sheet packing.

Engineers who get their boiler feed water from ponds, rivers or streams of any kind should investigate the Continuous Service Foot Valve. With this device water can be taken continuously without interruption from streams or ponds that are full of leaves, twigs, fish or other refuse such as often cause great annoyance and loss of time. Write for illustrated circular to The Newman Mfg. Co., 26 Cortlandt Street, New York City.

Mr. Frank P. Allen, an engineer and architect of wide experience and a native of Grand Rapids, Mich., has been appointed director of works of the Alaska-Yukon-Pacific Exposition, which will be held at Seattle during the summer of 1909. Mr. Allen is manager of the General Engineering and Construction Co., of Seattle and Portland.

It is claimed that Wolff belt dressing will preserve and clean either leather or rubber belts and that it is especially adapted for loose belts. A special feature of this dressing is that it requires no heating, being always ready for immediate use. A testimonial booklet and free trial offer will be mailed to anyone having belt troubles. Address The Norbert-Wolff Co., 472 Greenwich Street, New York City.

The following concerns have recently equipped their engine rooms with White Star continuous oiling systems:

New York, N. H. & H. R. R. Co., Readville, Mass.

Texarkana Gas & Electric Co., Texarkana, Ark.

Esmonde Mills, Enfield, R. I.

J. A. Roebling's Sons Co., Kinkara, N. J.

Reading Paper Mills, Reading, Pa.

Springfield Ry. Co., Springfield, Ohio.

Electric Developing Co., of Ontario, Niagara Falls, Ont.

Rockford Malleable Iron Co., Rockford, Ill.

N. R. & P. Consolidated Coal Co., Gentry, W. Va.

The Pittsburgh Gauge & Supply Co., 313 Water Street, Pittsburgh, Pa., will be pleased to send handsome descriptive booklets to those interested in this most modern method of economical lubrication.

The Pittsburgh Feed Water Heater Company, 716 Frick Building, Pittsburgh, Pa., have published a fine new catalogue for 1907 which is just off the press and is much larger than the last issue. It shows a number of new illustrations of heater installations, some of which are as much as ten thousand horse power capacity. A copy will be mailed upon request to any reader of this paper.

The new catalogue just issued by the Burt Mfg. Co., 204 Main Street, Akron, Ohio, is by far the best one ever published by that progressive concern. It contains 64 pages, 6x9 inches, on fine, heavy coated book paper, with numerous illustrations of exhaust heads, ventilators, oil filters and complete oiling systems, together with a vast amount of useful data which will be of value to engineers and others in charge of power plants.

The Cherry Chemical Co., 10 North Nineteenth Street, Philadelphia, manufacturers of the well known Red Seal boiler compounds, advise us that 1906 was one of the best years the company has ever had. They are now pushing hard for new business and are enrolling many new customers. They especially wish to correspond with engineers who can devote a portion of their time to their interests.

Engineers who are not familiar with the Hoppes steam specialties should get one of the catalogues issued by the Hoppes Mfg. Co., 70 Larch Street, Springfield, Ohio. These specialties have an individuality of design which not only stamps them as being different from most others, but a study of their construction may be productive of good in other ways. The Hoppes line includes heaters, separators, exhaust heads and a special feed-water purifier which has met with marked success. The Hoppes catalogue will be mailed to readers who are interested in any of these.

Circulars, prices and full details regarding the Patterson-Berryman feed-water heater, belt pumps for boiler feeding, etc., separators and exhaust heads, may be had by addressing Frank L. Patterson & Co., 24 Cortlandt Street, New York.

It may surprise many engineers to know that a large majority of steam gauges which have been in use for any considerable length of time are incorrect, often registering many pounds more or less than the true pressure. All gauges should be tested frequently, but the means for doing so is not always at hand. The American Dead Weight Tester is an inexpensive and excellent device for this purpose and has met with popular approval. It is manufactured by the American Steam Gauge & Valve Mfg. Co., Boston, Mass. A special circular will be mailed upon request.

The Buckeye Boiler Skimmer Co., of Toledo, Ohio, have received the following testimonial letter from the Cadick Milling Co., Grand View, Ind.:

Grand View, Ind., Oct. 7th, 1906.

The Buckeye Boiler Skimmer Co.,
Toledo, Ohio.

Gentlemen:

Replying to your favor of the 5th, would say that the Buckeye Skimmers which we purchased from you are working very satisfactorily. We are using Stirling water-tube boilers, and had quite a lot of trouble with our boilers fermenting and drawing over into the engine before placing your Skimmers in them, but since we have installed your Skimmers we have had no trouble at all.

We are using very hard water, full of alkali, and the two boilers were as clean last washout day as if they had been cleaned out. In fact, we think your Skimmer a very valuable addition to our boiler plant, and you can refer any prospective buyer to us for any information they may want, as well as to how we are pleased with your Skimmer, and we will take pleasure in recommending your Skimmers to them.

Very truly
CADICK MILLING CO.,
(Signed) By D. E. Cadick, Sec & Treas.

The Ashton Valve Co., of 271 Franklin St., Boston, Mass., are issuing a very attractive catalogue in colors, a copy of which will be sent to those requesting it.

The Hartford Engine Works, of Hartford, Conn., have just finished reboring and refitting the engines of the Crocker, McElwain Co., of Holyoke, Mass., these being the first repairs that have been put on these engines since they left the shops of the Hartford Engine Works in 1883. The Hartford Engine Works have also received a contract to rebore and repair a 1500 H. P. Cross-compound Engine at Holyoke, for which they are designing some new machinery embodying their patent boring apparatus.

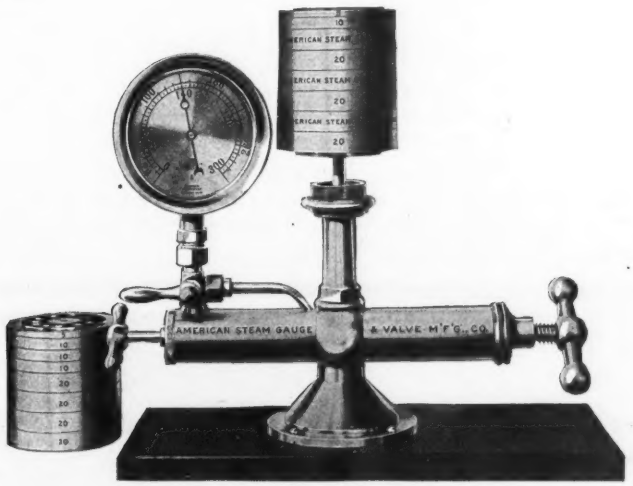
A Square Deal To Every Man

You know we make power plant specialties; high grade specialties. We've been at it for fifty years and we have been highly successful. It's but natural that we are able to make what we make as good as it is possible for such things to be made.

To our ability to make "American" Specialties RIGHT, is joined the wisdom to sell them RIGHT, in other words, backed by a guarantee that means your money back if not satisfied.

Customers know that if we cannot supply them with an "American" Specialty to suit their peculiar case, we do not hesitate to say so, and incidentally to give them the benefit of our half-century's experience by advising them what to do. We are ready to serve you in the same way—at any time.

We make THE AMERICAN-THOMPSON IMPROVED INDICATOR; THE AMERICAN COMBINED PRESSURE AND RECORDING GAUGE; THE AMERICAN SPECIAL POP SAFETY VALVE, all of which are recognized as standards of quality; also other engine room specialties. Write for details of anything you need.



Incorrect Gauges Are Wasteful---Are Yours Correct?

This American Dead Weight Tester was designed especially to correct Steam Gauges that register incorrectly, and consequently cause a great waste of fuel by misleading the engineer or fireman. As its name implies, it tests by actual *dead weights,* and is therefore much more accurate as a standard, than comparisons, when made with a pump and test gauge.

The American Dead Weight Tester is the most scientific, most accurate and trustworthy instrument ever invented for testing gauges. With it you can test your gauges and easily determine whether they are correct, or remain at the set pressure even after several more pounds of steam are generated and much coal wasted.

If you want this guide to economy, address Dept. F. for full particulars.

MANUFACTURED EXCLUSIVELY BY THE

American Steam Gauge & Valve Mfg. Co.

No. 208 to 220 CAMDEN STREET

NEW YORK
ATLANTA

BOSTON, MASS.

CHICAGO
SAN FRANCISCO

The Walsh Packing Co. wish to announce that they have removed from 1118 S. 7th St. to 304 New St., Philadelphia, where they will be pleased to receive their old customers. The removement to the larger quarters was necessitated by their rapidly increasing business.

There is a world of satisfaction, when you make your rounds in the morning or evening, in being able to know just what your boiler pressure has been during the night or day preceding, and just what variations have occurred. The Ashton Pressure Recording Gauge registers the pressure constantly and gives you a written record covering every minute of the day or night. These records are invaluable; they encourage constant vigilance, contribute to economical production and aid the engineer in determining efficiencies. The Ashton catalogue, giving full description of this and other instruments, will be mailed upon request. Address Ashton Valve Co., 271 Franklin Street, Boston, Mass.

M. T. Davidson, manufacturer of the old reliable Davidson steam pumps, has moved his offices from 141 Broadway, where he has been located for years, to larger and finer offices in the Tribune Building, New York, where engineers and customers visiting New York are cordially invited to call.

We have received from Messrs. Adam Cook's Sons, 313 West Street, New York City, the only makers of "Albany Grease," a new booklet which they have just isssued dealing with "Automobile Lubrication." It consists of sixteen pages with an atractive cover in two colors, and the text is interspersed with drawings showing just how "Albany Grease" is applied in packing compression cups, transmission gears, etc. Other interesting facts will be gleaned from the booklet, a copy of which will be cheerfully mailed to readers who make application.

Clement Restine Company, 133 North Second Street, Philadelphia, have in press a large handsome new catalogue of 100 pages, size 6x9 inches, and 80 illustrations, which is devoted exclusively to packings. This promises to be one of the most complete packing catalogues yet issued. Copies will be mailed to at once to the above address.

Spangenberg's "Steam and Electrical Engineering" is a book of 672 pages, with 648 illustrations and 1035 questions and answers covering about everything that can come up in a power plant. It is very thoroughly described in a new 52-page pamphlet, which will be sent free by the publishers, George A. Zeller Book Co., 62 South Fourth Street, St. Louis, Mo.

James Bonar & Co., Inc., of Pittsburgh, have secured Mr. David M. Kerr, of Detroit, Mich., to represent them in that district for the sale of Pittsburgh Feed Water Heaters, Bonar Oil Filters, Bonar Gauge Cocks, Bonar Exhaust Heads, etc.

Mr. Kerr has made a good beginning, selling two 1500 H. P. heaters and some exhaust heads to the American Car & Foundry Co., of Detroit, Mich.

GRAPHO
SOMETHING NEW
A new preparation for enriching oils.
Will suspend in oil.
No more Hot Journals.
Engineers who have tried same claim it to be the best yet.
SEND FOR SAMPLE
A trial will convince you
AGENTS WANTED
GRAPHO MFG. CO.
Cor. Frank and Commercial Sts.
ROCHESTER, N. Y.

The indicator free with the course of instruction which has been offered for over two years by the Indicator Instruction Co., Newark, N. J., is about to be cancelled, as this company states that it is impossible for them to continue to give a first-class indicator at this price and come out even, much less make a profit. This feature was instituted as an advertising venture, but they hoped to continue it indefinitely, and probably would have done so had it not been for the extremely rapid increase in the cost of material and labor. Those who wish to get a perfectly reliable engine indicator with or without instructions should immediately correspond with A. C. Lippincott, General Manager, 50 Columbia Street, Newark, N. J., who will send a fine catalogue and full particulars by return mail.

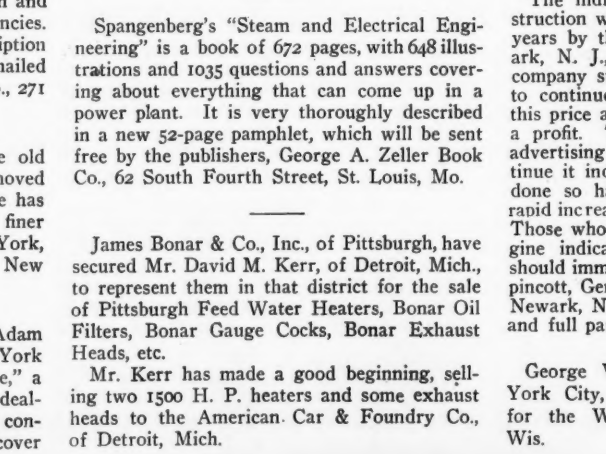
George Woolston, of 66 Broadway, New York City, represents the Eastern Territory for the Wisconsin Engine Co., of Corliss Wis.

1035 Questions and Answers

Asked by Different Examining Boards throughout the Country.

648 ILLUSTRATIONS

672 PAGES



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PRACTICAL KNOWLEDGE IS MONEY.

The highest salaries come to "the men who know." Here's a book teeming with good practical information for engineers---steam and electrical. It is the engineer's text book, his reference book, his authority. An Encyclopedia of information, and in itself the most complete library of engineering practice ever published. Treating on **Stationary Engineering, Locomotive Engineering, Electricity, Compressed Air, Mechanical Refrigeration, Gas and Gasoline Engines, Hydraulic Elevators and Repair Work.** If you want a complete work written in a simple and direct style, get this one and make no mistake. New 25 page pamphlet sent free.

GEO. A. ZELLER BOOK CO., Publishers,
(ESTABLISHED 1870.)
62 South Fourth Street, Saint Louis, Mo.